UNCLASSIFIED

AD NUMBER
AD864882
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 10 FEB 1970. Other requests shall be referred to Air Force Technical Applications Center, Washington, DC 20333.**
AUTHORITY
AFTAC USAF ltr 25 Jan 1972

THIS PAGE IS UNCLASSIFIED

AD 864882

AFTAC Project No. VT/9707

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Chief, AFTAC

Alexandria, Va. 22313

LONG PERIOD ARRAY PROCESSING DEVELOPMENT

Quarterly Report No. 3

1 November 1969 to 31 January 1970

T. W. Harley, Program Manager
Area Code 292, 244-4894

TEXAS INSTRUMENTS INCORPORATED
Services Group
P. O. Box 5621
Dallas, Texas 75222

Contract No. F33657-69-C-1063
Amount of Contract: $391,000
Beginning 21 April 1969
Ending 21 February 1971

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER
Washington, D.C. 20333

Sponsored by

ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Monitoring Research Office
ARPA Order No. 624
ARPA Program Code No. 9F10

D D C
FEB 12 19
B

10 February 1970

Acknowledgment: This research was supported by the Advanced Research Projects Agency, Nuclear Monitoring Research Office, under Project VELA-UNIFORM, and accomplished under the technical direction of the Air Force Technical Applications Center under Contract No. F33657-69-C-1063.

Reproduced by the
CLEARINGHOUSE
for Federal Scientific & Technical
Information Springfield Va. 22151

AFTAC Project No. VT/9707

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Chief, AFTAC

LONG PERIOD ARRAY PROCESSING DEVELOPMENT

Quarterly Report No. 3

1 November 1969 to 31 January 1970

T. W. Harley, Program Manager
Area Code 292, 244-4894

TEXAS INSTRUMENTS INCORPORATED
Services Group
P. O. Box 5621
Dallas, Texas 75222

Contract No. F33657-69-C-1063
Amount of Contract: $391,000
Beginning 21 April 1969
Ending 21 February 1971

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER
Washington, D. C. 20333

Sponsored by

ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Monitoring Research Office
ARPA Order No. 624
ARPA Program Code No. 9F10

10 February 1970

Acknowledgment: This research was supported by the Advanced Research Projects Agency, Nuclear Monitoring Research Office, under Project VELA-UNIFORM, and accomplished under the technical direction of the Air Force Technical Applications Center under Contract No. F33657-69-C-1063.

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Chief, AFTAC.

Qualified users may request copies of this document from:

Defense Documentation Center
Cameron Station
Alexandria, Virginia 22314

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

BLANK PAGE

SECTION I
INTRODUCTION AND SUMMARY

This third quarterly report describes progress made during the period 1 November 1969 to 31 January 1970 on the Long Period Array Processing Development program being conducted by Texas Instruments at the Seismic Array Analysis Center (SAAC). The purpose of the program is to develop on-line and off-line software and to use the software to evaluate the detection and discrimination capabilities of the Alaskan Long Period Array (ALPA).

The on-line package has been described previously in Quarterly Reports No. 1[1] and No. 2[2]. It acquires data from the ALPA-SAAC transmission link and performs quality checks, beamforming, recording and display of the ALPA data and provides operational status summaries. Software effort in the last quarter has been directed toward modifying the package to operate in the foreground partition of the NORSAR S360/40. This mode of operation allows the 75% to 80% of the S360/40 Central Processing Unit (CPU) not required for ALPA on-line processing to be utilized for job shop operations. Refinements to the tape format and SAAC develocorder subtask also were completed.

During December and January the on-line package was run for periods of up to 12 hours. These samples were used to assist Geotech personnel in checking out their software at the Maintenance and Monitoring Center (MMC) in Alaska and to provide them with information on the data quality of operational seismometers. The on-line package will be implemented on a continuous basis early in February.

The off-line package has been described previously in Quarterly Reports No. 1[1] and No. 2[2]. Functionally the package can be divided into three parts, data selection (selection, editing and quality checking of data to be processed),signal enhancement processing (generation of the noise spectral matrix, multi-channel filter design and filter application) and analysis processing (signal and noise analysis and discrimination analysis). The data selection software has been completed, the signal enhancement software is nearing completion, the analysis software has been defined and parts have been completed. During the next three months coding and checkout of the off-line package will be completed and off-line evaluation will begin. Software effort after this phase will consist of upgrading existing software and incorporating signal processing techniques which have been shown useful by studies conducted on the Seismic Array Data Processing Techniques program being conducted by TI in Dallas.

SECTION II
ON-LINE PACKAGE

A. INTRODUCTION

Quarterly Reports No. 1 and 2 have described the functions, data flow and structure of the on-line package. This report will summarize modifications made to the on-line package during the last quarter, describe the initialization and update tasks in more detail, and review operation of the package to date.

The major programming effort during the last quarter involved modifying the on-line package so that it could operate in the foreground partition of the NORSAR S360/40. By operating the ALPA on-line package, which takes between 15% and 20% of the Central Processing Unit (CPU) capacity in the foreground partition, the remaining CPU capacity can be utilized for other processing unrelated to ALPA. Thus the overall computation capacity of SAAC is significantly higher than if the NORSAR S360/40 were dedicated solely to ALPA on-line processing. The program modifications involved the control task and the frame and block processor subtasks and are described later in this section.

The initialization routine is used to initiate ALPA on-line processing. Flow diagrams for this routine are presented in this section and the card input formats are detailed in Appendix A. The update subtask allows on-line modification of ALPA processing parameters; a summary of all possible updates is presented in Appendix B.

A detailed description of the ALPA library tape format was submitted to AFTAC on 1 December 1969; the format is set up to be compatible for both S360/40 and SPS ALPA on-line processing. Since 1 December, a few minor additions to the tape format have been made; a complete current ALPA library tape format is given in Appendix C.

During December and January the on-line package has been run several times for periods of up to 12 hours to collect data samples from ALPA. These samples have been used to support Geotech personal in their debugging of the ALPA MMC software and to evaluate the quality of the seismic data being transmitted from ALPA. Results of these analyses are described briefly in this section.

B. PACKAGE CONFIGURATION

1. Modifications for Partitioned Operation

a. General

Since the ALPA on-line package needs only 15% to 20% of the NORSAR S360/40 CPU capacity, the remaining computational capacity could be employed by other jobs running concurrently on the machine. To accomplish this mode of operation the S360/40 supervisor was designed to divide the machine into three partitions; foreground 1, foreground 2 and background. The on-line package resides in foreground 1 and so has highest CPU priority.

In the partitioned mode of operation the supervisor assigns periphery devices to a particular partition. It is desirable to assign the printer to the background partition since most jobs that are run in background require the use of a printer. Note, however, that the on-line package also requires a printer for messages from the frame processor and for the block processor summary printout. Since only one printer is available to the NORSAR S360/40 and, further, since the printer must be available to background partition jobs if effective use is to be made of the available CPU capacity, the on-line package was revised so that the printer could be assigned to the background partition and the required printed output from the on-line package still could be obtained. Modifications to the control task, the frame processor and the block processor were required; these are described in subsequent subsections. Figure II-1 shows the revised data flow for the on-line package.

b. Control Task

Figure II-2 shows the main flow for the control task. (this figure updates Figure II-2 of Quarterly Report No. 2) An additional step, namely opening the disk for "spooling" the block processor printout (Section II-1-d) is required for partitioned operation. In addition, the steps in terminating the on-line package are described in more detail.

c. Frame Processor

Messages from the frame processor are irregular and generally short in nature. In addition, they normally indicate an error condition and so it is important that they be displayed immediately. Thus messages from the frame processor have been transferred from the printer to the console typewriter. In the process of transferring the frame processor printout to the typewriter, the format was standardized and the timing tag made consistent with the timing tag typed by the update insertion subtask. At the same time, minor bugs connected with infrequently encountered tape error conditions were corrected.

d. Block Processor

In order to obtain the summary printout from the block processor a technique known as "spooling" was

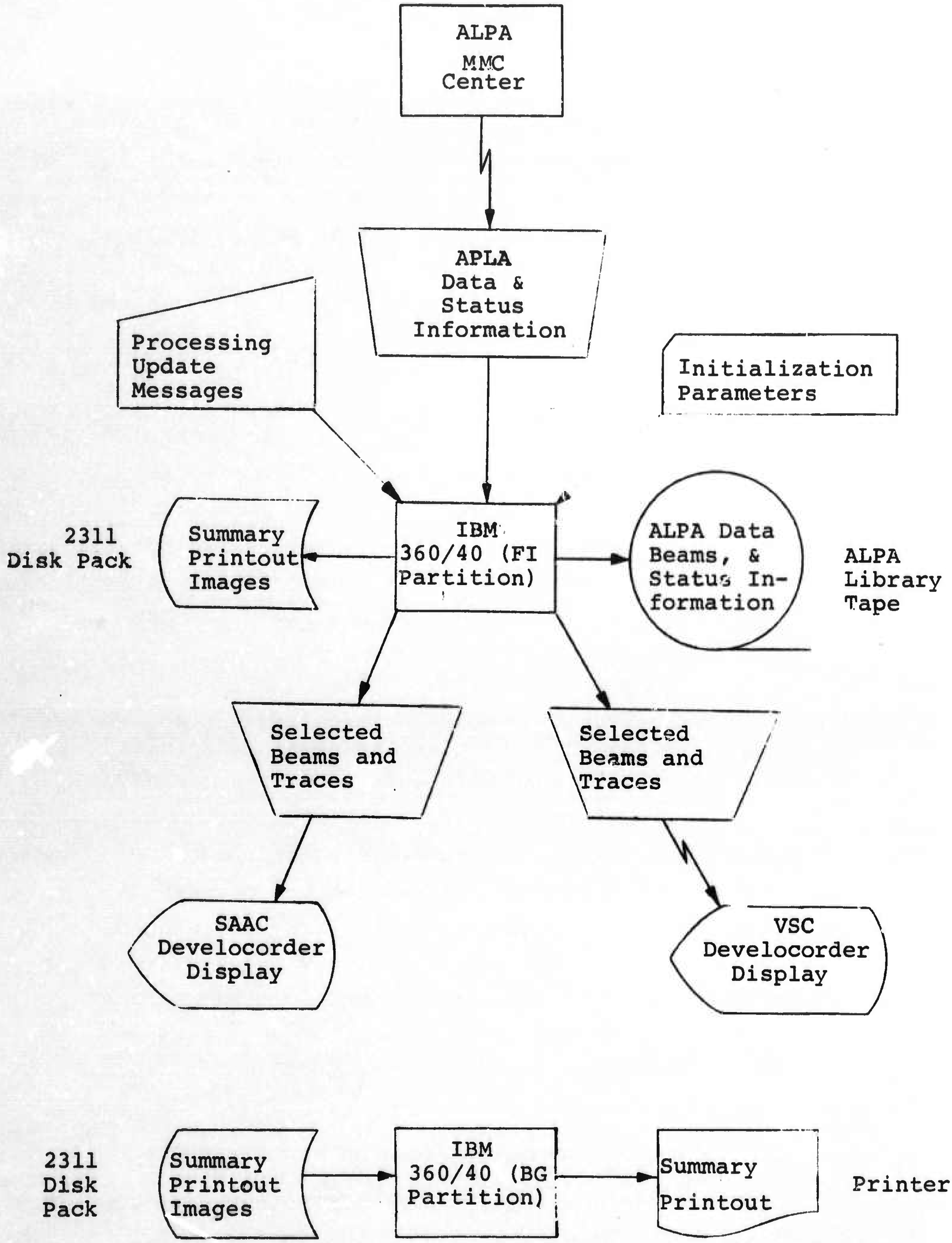


FIGURE II-I
ON-LINE DATA FLOW

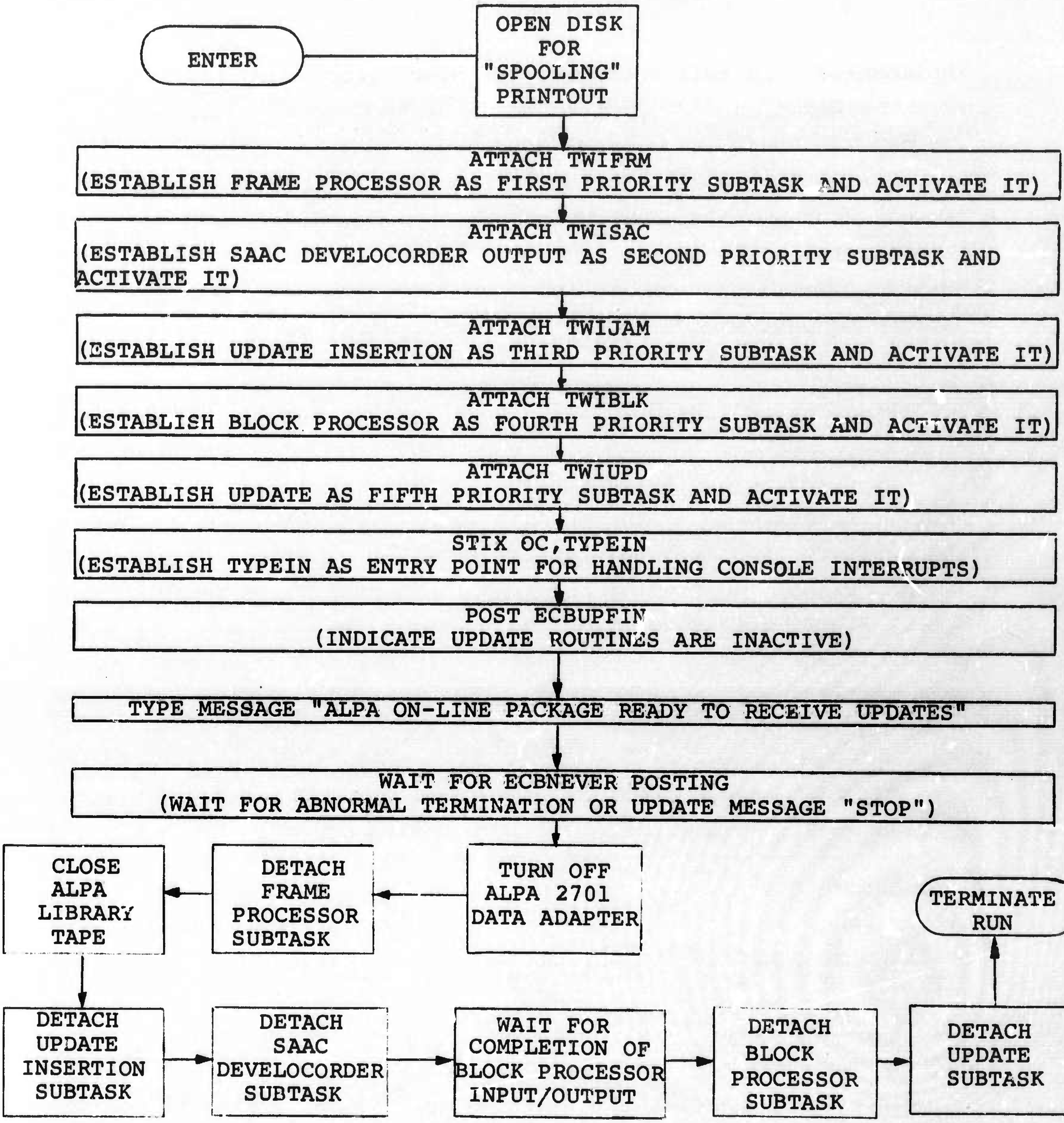


Figure II-2

CONTROL TASK
(MAIN FLOW)

implemented. In this technique the block processor printout is transferred to a 2311 disk pack storage device using logical I/O Control System MACROS. When half the 2311 storage area is filled with ALPA printout information, a message is sent to the operator, who loads a background partition ALPA print program that outputs the information on the printer. Between executions of this ALPA print program, the background partition is available for processing unrelated to the ALPA processing.

2. Initialization Routine

The inialization routine was described in Section II-B-2 of Quarterly Report No. 2. Figures II-3 and II-4 are flow diagrams for this routine. Figure II-3 shows the input sequence for initializing processing parameter, Figure II-4 shows the flow followed in constructing certain areas of core and preparing for on-line operation. The specific card input for the processing parameters is given in Appendix A.

3. SAAC Develocorder Subtask

The SAAC develocorder subtask was rewritten to implement a new method of sychronizing the ALPA transmissions and develocorder output. In addition, a message "SAAC DEVELOCORDER INTERRUPT RECEIVED" was incorporated at the point where the first output transmission to the develocorder is made. This message permits the user to know immediately the on/off status of certain equipment associated with the develocorder. Figure II-5 shows the modified flow diagram for the SAAC develocorder subtask.

4. Update Subtask

The update subtask allows the operator to change

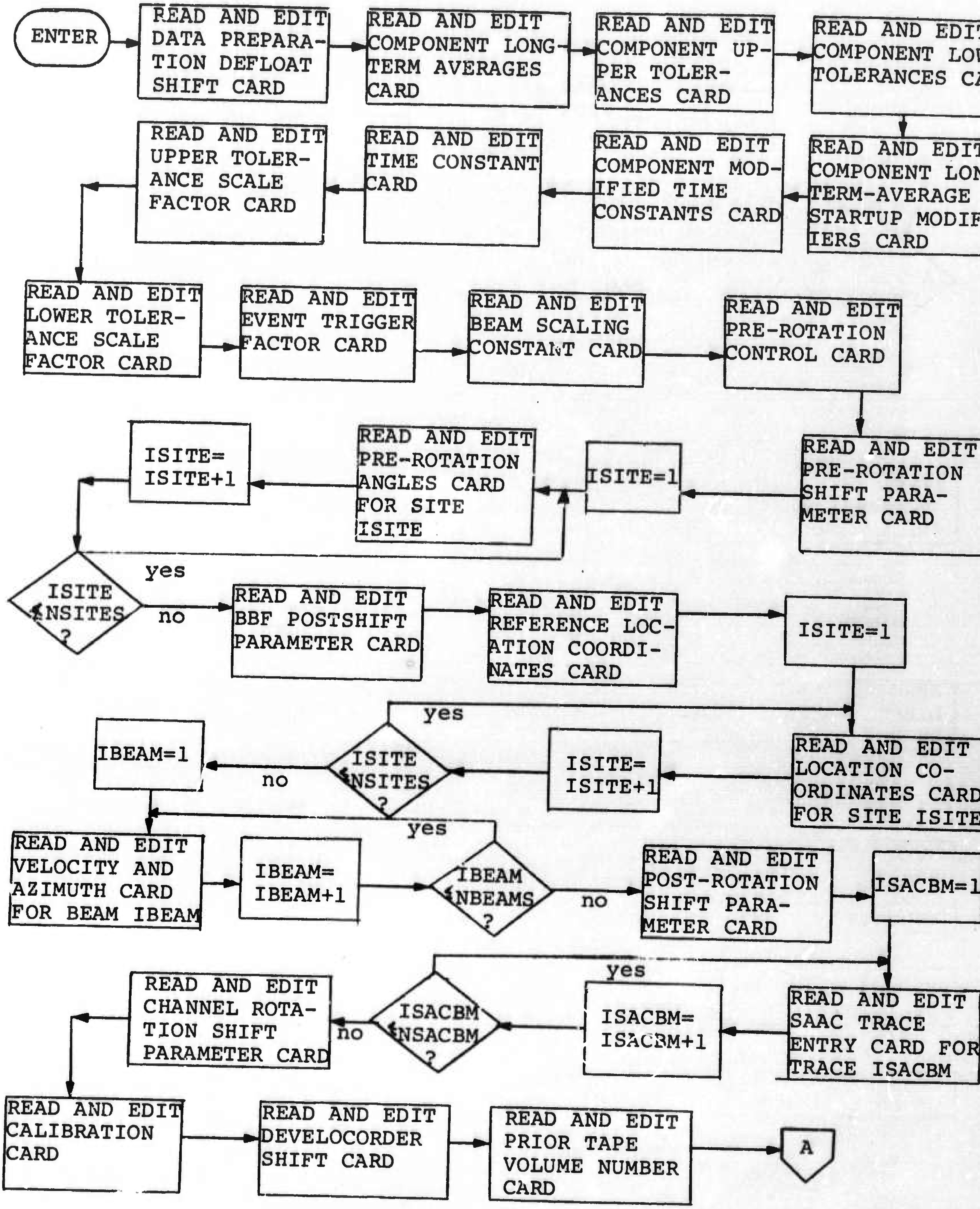


FIGURE II-3
INITIALIZATION ROUTINE
(INPUT)

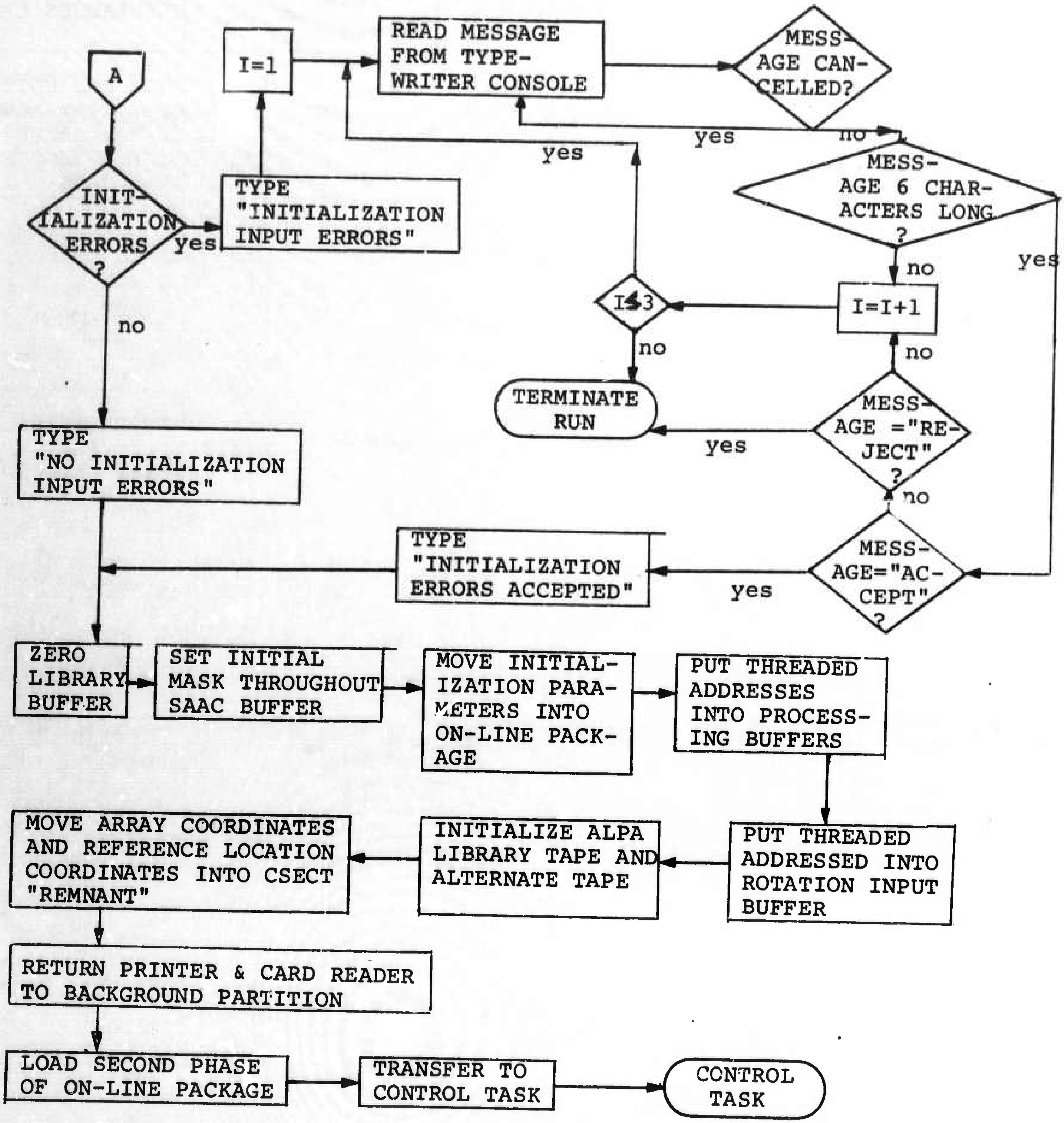


FIGURE II-4
INITIALIZATION ROUTINE
(INITIATE ON-LINE PACKAGE)

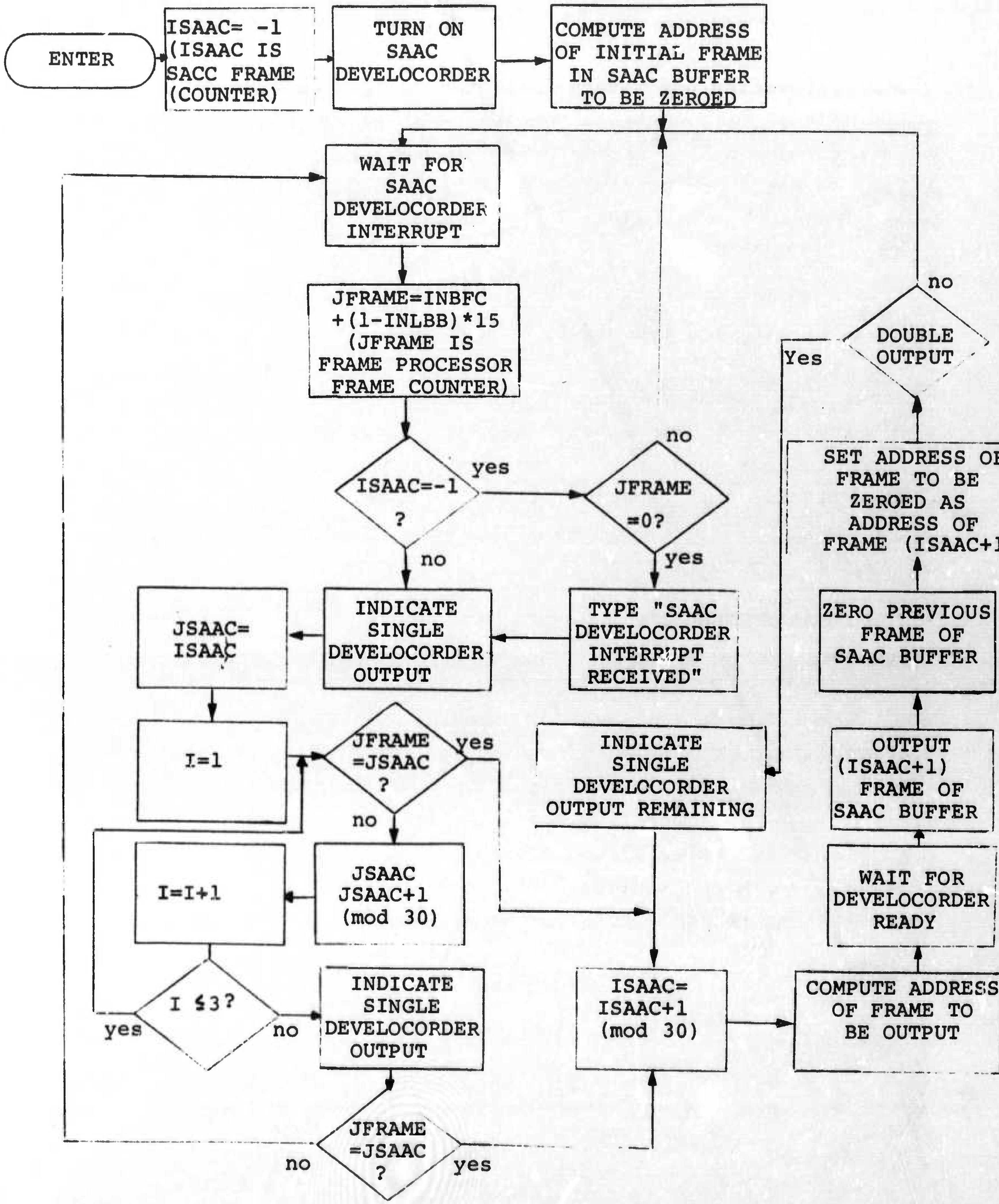


Figure II-5

SAAC DEVELOCORDER SUBTASK

ALPA processing parameters while the on-line package is operating. Flow diagrams for this section of the on-line package have been given in Quarterly Report No. 2. The updates which are possible are describes in Appendix B.

C. LIBRARY TAPE FORMAT

The ALPA library tape format was defined jointly by TI and IBM and summarized in a memo to AFTAC dated 1 December 1969. The primary objective was to make the format consistent for both NORSAR S360/40 and SPS ALPA on-line processing. Since 1 December 1969, a few more modifications have been made to the format, primarily to make the ALPA library tape consistent with other IBM tape formats. A current definition of the ALPA library tape format is given in Appendix C.

D. PACKAGE OPERATION

1. ALPA MMC Software Support

During the month of December, the first transmissions from the ALPA Maintenance and Monitoring Center were received. A program was written to print the transmissions as received from the ALPA library tape. The printouts were used by Geotech to aid in eliminating several software problems affecting the ALPA transmissions. Among these software problems were:

- Site error table and seismometer function table settings not corresponding to the seismometers which were up
- A buffering problem in which zeroed and erroneous data were received at some seismometers every other second

- Unnormalized gain-ranged data points (reducing the dynamic range of the data)
- Illegal gain codes in some of the data points
- Improperly incrementing timing codes.

During early January, most of these problems were eliminated by Geotech.

2. ALPA Data Quality Evaluation

Preliminary analysis of ALPA data recorded at SAAC has been performed during the month of January. The analysis has been aimed at obtaining an estimate of the quality of the data as it is received in Washington, and to point out possible problem areas. Data types examined include several samples of ambient noise, system noise tests and calibrations at sites 1, 3, 4, and 5 and two events. Outputs include plots and mean square values of the wiggly traces, DC levels in the data, power density spectra and selected two-channel coherencies. The results of this analysis are routinely reported to ALPA and to VSC personnel. This effort will be continued in support of the array installation.

E. STATUS

The on-line package will be implemented on a continuous basis early in February. All modifications necessary for partitioned operation have been made and on-line checkout is currently in progress.

Two significant on-line efforts remain to be completed; formatting data for the VSC develocorder and implementing an on-line adaptive beamforming algorithm. Definition of each task has been completed and these efforts will be completed by the end of February and end of March respectively.

SECTION III
OFF-LINE PACKAGE

A. INTRODUCTION

In previous quarterly reports, the basic off-line software organization and approaches have been discussed. The data preparation programs QCEDIT and NOISE have also been examined in detail. In this quarterly report the off-line software configuration, including a summary of the functions of main-line software packages, will be brought up to date. The signal enhancement programs and tape usage also will be discussed and current status and future plans will be reviewed.

B. GENERAL PROCESSING FLOW

Figure III-1 is a generalized flow diagram which describes the off-line data flow and summarizes the functions of the main-line software programs. The programs SELECT and QCEDIT perform the editing functions of the off-line package. Events and noise samples are edited from the ALPA library tapes onto signal and noise tapes. During editing the data are quality checked and corrected when possible. Note that the develocorder film and summary printout, two functions of the on-line package, will play a significant part in the selection of events for processing.

The programs NOISE, MCFGEN and TDFILT perform the signal enhancement function of the off-line package. The program NOISE generates the noise cross-power spectral matrix(CPS) which is saved on tape. MCFGEN reads the noise CPS, generates theoretical signal models and solves for the optimum filter associated with each signal model. These frequency domain

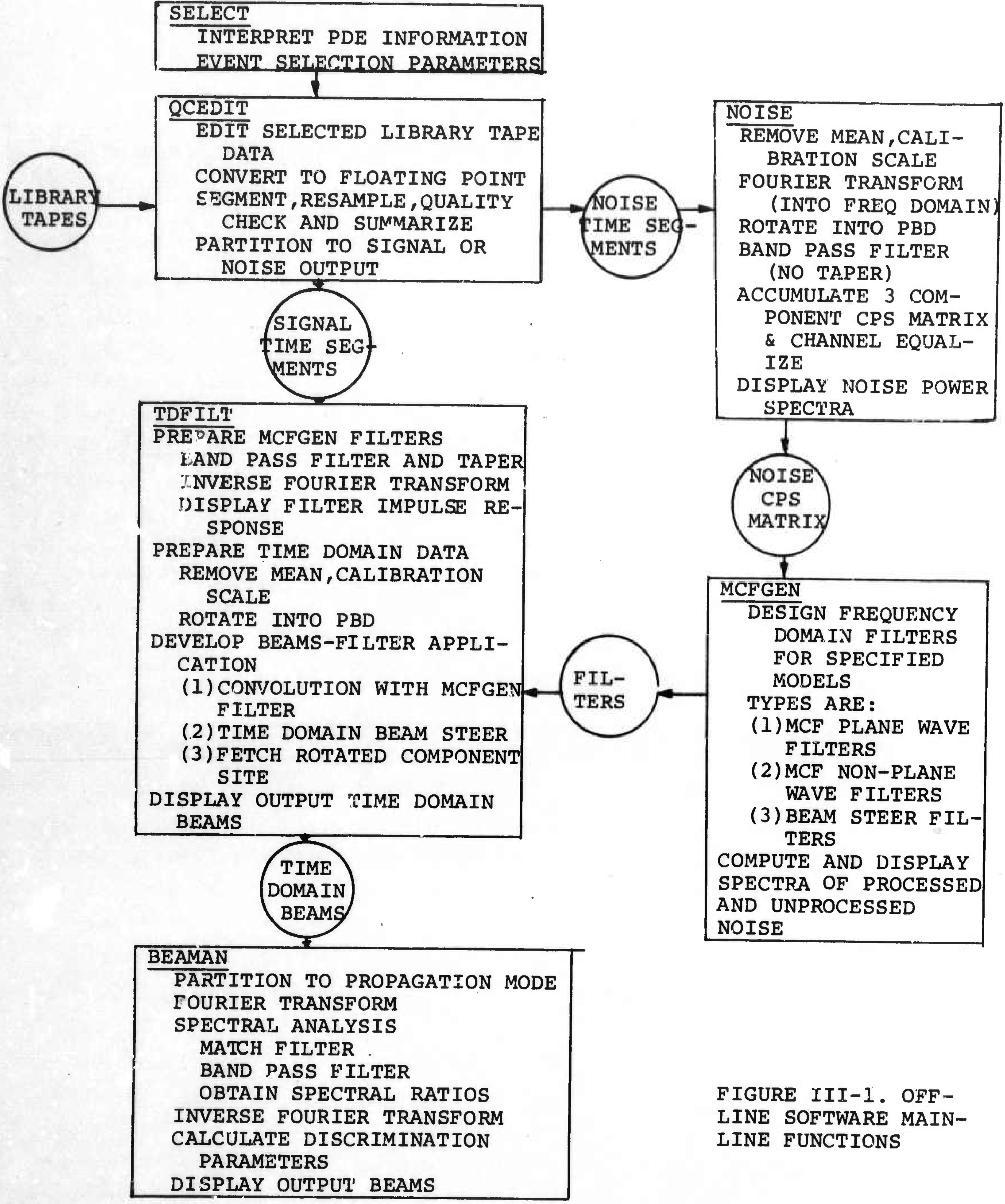


FIGURE III-1. OFF-LINE SOFTWARE MAIN-LINE FUNCTIONS multichannel filter sets are output on magnetic tape. The program TDFILT reads the multichannel filter sets, inverse transforms the filters and applies the filters to appropriate segments of the signals. The outputs of TDFILT are the optimum signal estimates for each phase; these data are written on magnetic tape and can be plotted.

The program BEAMAN performs special single channel processing options such as simple bandpass filtering and matched filtering and calculates discrimination parameters for the event.

The software is set up so that several events can be processed each time a main-line program is run. For example, QCEDIT can be set up to edit five events and their associated noise samples from the ALPA library tapes on one run. This multiple event processing philosophy will be used in the off-line evaluation (but of course single events also can be processed when the occassion demands).

Another important feature of the off-line package is that all important intermediate outputs are saved on magnetic tape. This allows the analyst to recycle his processing for a given event with a minimum of effort and computer time and also provides easily accessible input to non-routine off-line programs such as NOISAN (Noise analysis) and SIGNAN (Signal analysis).

C. PROGRAM DESCRIPTION

1. MCFGEN

Frequency domain MCF and beamsteer filters are designed in the program MCFGEN. The primary filter design input is the measured noise cross-correlation matrix FDCPS-3C. MCFGEN outputs include: filter sets, FDFILTAB, the power spectra of processed and unprocessed noise, FDPS, and printer plots.

The basic MCFGEN processing flow is shown in Figure III-2. As for most off-line programs, the filter design package batches the processing of events and utilizes overlapped I/O and CPU activity whenever possible. MCFGEN has much analytical flexibility with options such as:

- Filter type-plane wave or non-plane wave MCF (or beam steer)
- Site configuration-the arbitrary deletion of sites for a particular filter set
- Azimuth
- Signal to noise ratio
- Dispersion characteristics.

Table III-1 provides a list of the parameters which define a filter set.

MCFGEN is programmed to minimize redundant computation; specifically, phase vectors are computed during initialization and later fetched as needed, rather than being recomputed whenever needed. The number of matrix triangularizations are minimized in much the same fashion.

MCFGEN basic flow is expanded in Figures III-3 through III-5. Figure III-3 shows the processing initialization for a particular event. Figure III-4 shows the noise CPS input and smoothing flow and the phase vector initialization for a particular frequency. Figure III-5, Parts A through D, detail the specifics required for the design of a filter at a particular frequency.

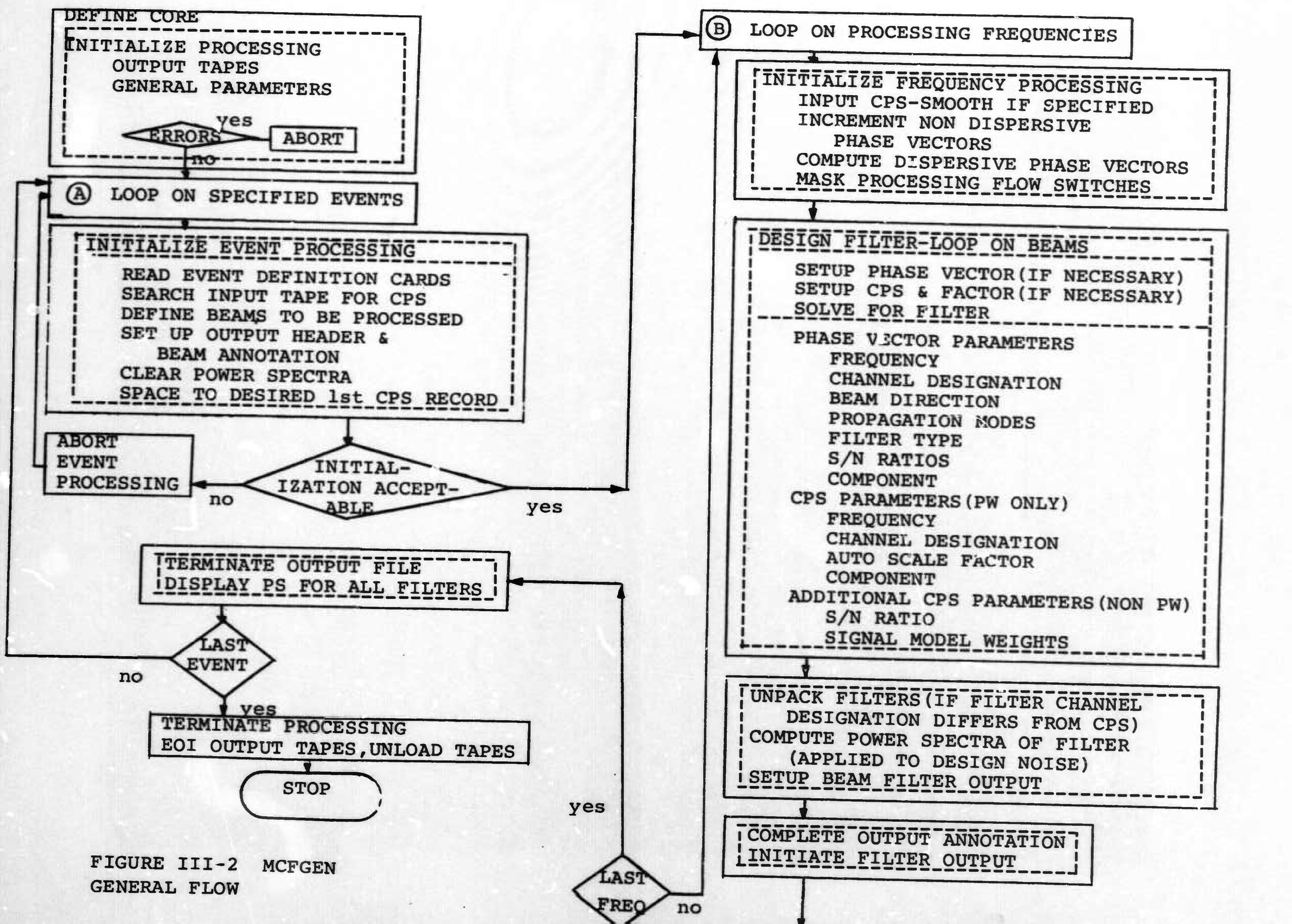


FIGURE III-2 MCFGEN
GENERAL FLOW

TABLE III-1
BEAM ANNOTATION SPECIFICATION

TYPE	INDEX	DESCRIPTION	OPTION	
ALPHA	1	FILTER TYPE	MCFb	MULTI-CHANNEL PLANE WAVE
			BSbb	BEAMSTEER PLANE WAVE
			MCFX	OTHER (i.e. NON PW MCF)
ALPHA	2	PROPAGATION MODE	Pbbb	PRIMARY
			Sbbb	SHEAR
			LQbb	LOVE
			LRbb	RAYLEIGH
ALPHA	3	DISPERSION CODE	DISP	DISPERSIVE
			NDIS	NON DISPERSIVE
ALPHA	4	COMPONENT	Vbbb	VERTICAL
			Tbbb	TRANSVERSE
			Rbbb	RADIAL
ALPHA	5	ORIENTATION CODE	PBDb	PRIMARY BEAM DIRECTION
			SBDb	SECONDARY BEAM DIRECTION
			VENb	VERTICAL, EAST, NORTH
FLOATING	6	BEAM AZIMUTH		
FLOATING	7	(RESERVED)		
FLOATING	8	PROPAGATION VELOCITY - VARIABLE WITH FREQUENCY AND SHOULD NOT BE DEFINED WITH THE "FDFILT19" HEADER.		
INTEGER	9	#SITES PROCESSED $1 < NCHAN \leq 19$		
BINARY	10	COMPONENT PROCESSING STATUS TABLE (NCHAN BITS OFF)		
"	11	" " " "		
INTEGER	12	REFERENCE SITE INDEX ON PACKED DATA		
FLOATING	13	S/N RATIO (POWER)		
ALPHA	14	SIGNAL MODEL TYPE	PWbb	SINGLE PLANE WAVE
			SUPW	SUPERPOSITION OF PW's
FLOATING	15	PROCESSED NOISE POWER SPECTRA - ACTUAL POWER OF FILTER FPM WITH PRE AND POST-MULTIPLIED NOISE MATRIX - VARIABLE WITH FREQUENCY.		

NOTE: b indicates blank

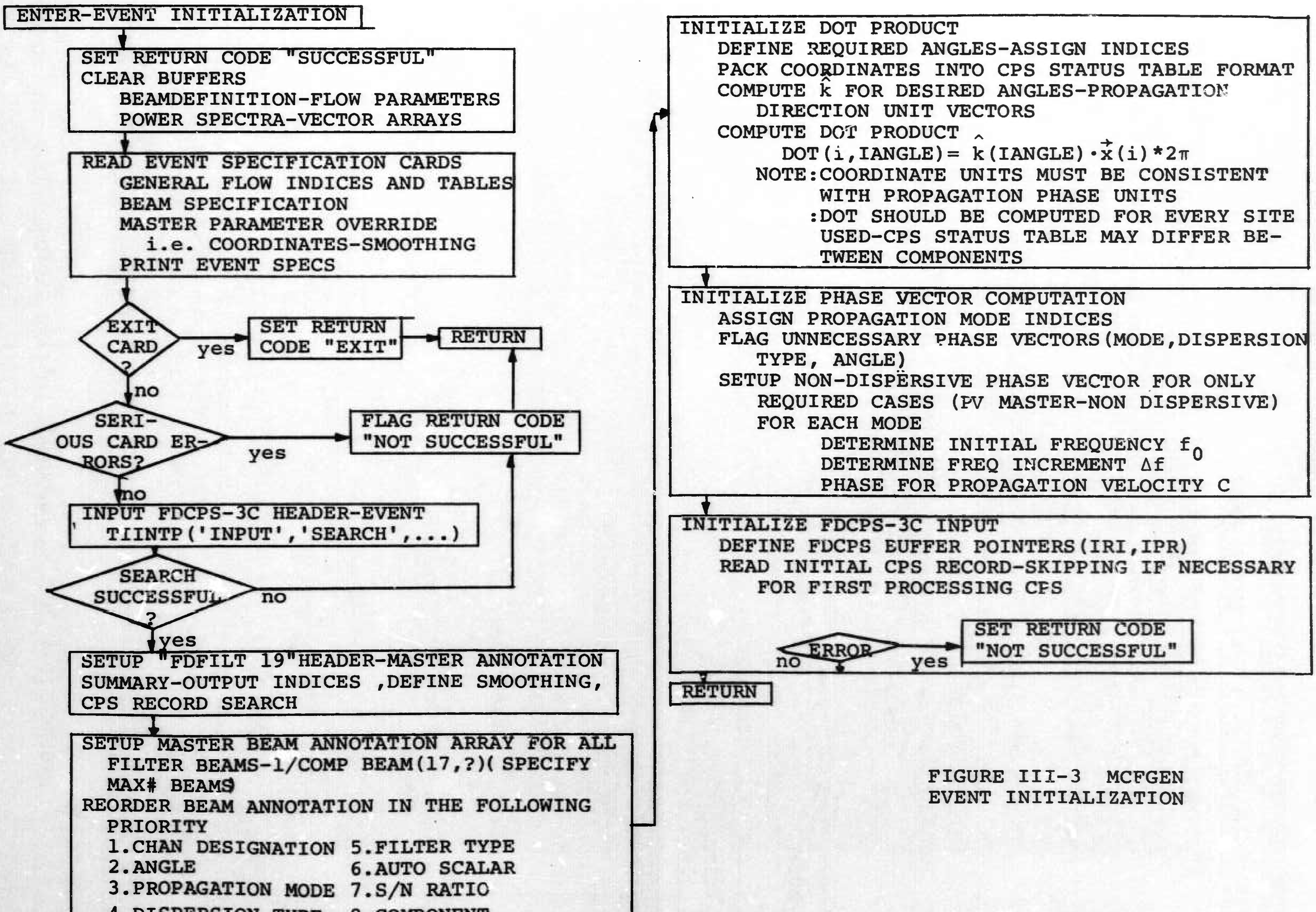


FIGURE III-3 MCFGEN
EVENT INITIALIZATION

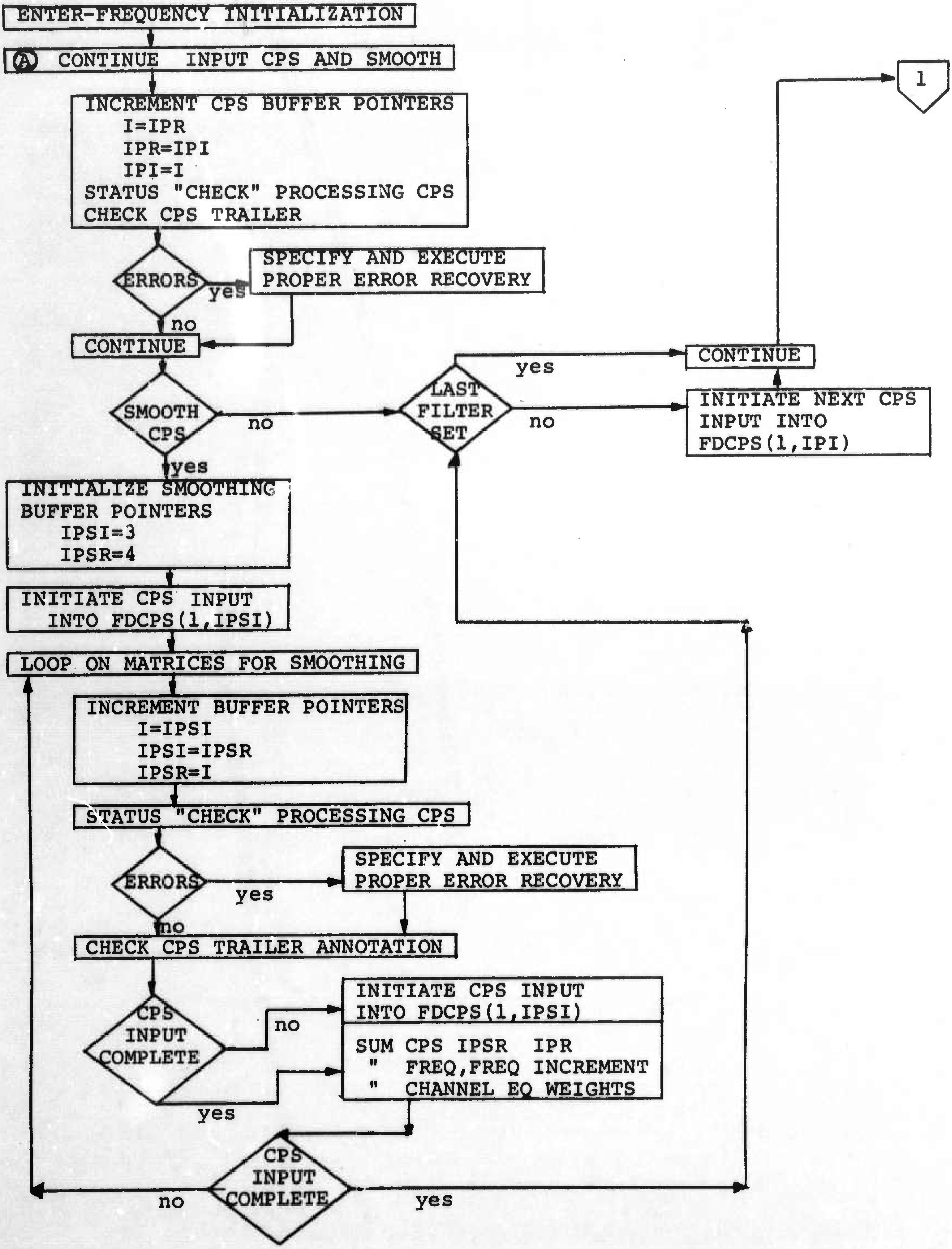


FIGURE III-4 MCFGEN FREQUENCY INITIALIZATION

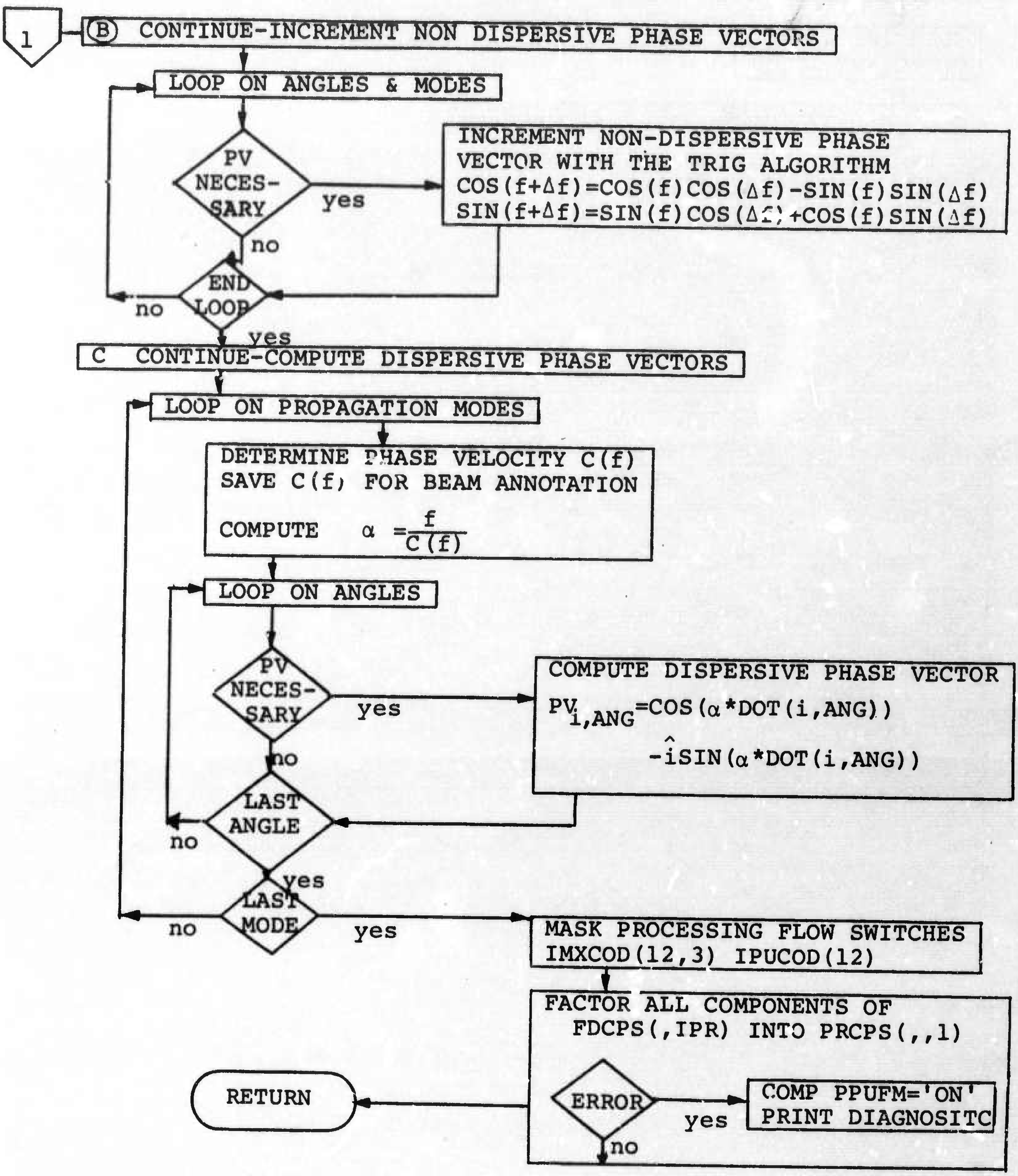


FIGURE III-4 (continued)

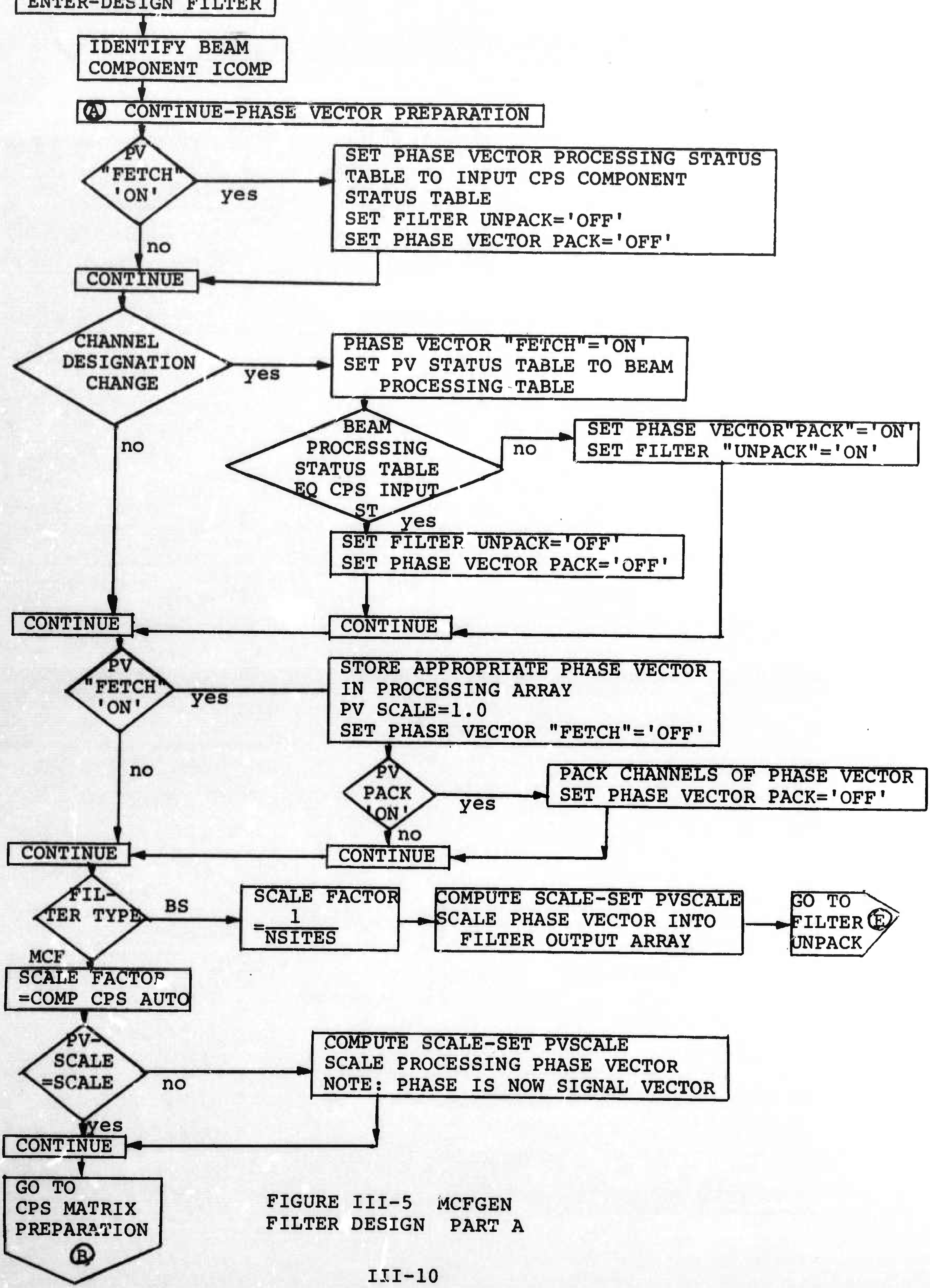


FIGURE III-5 MCFGEN
FILTER DESIGN PART A

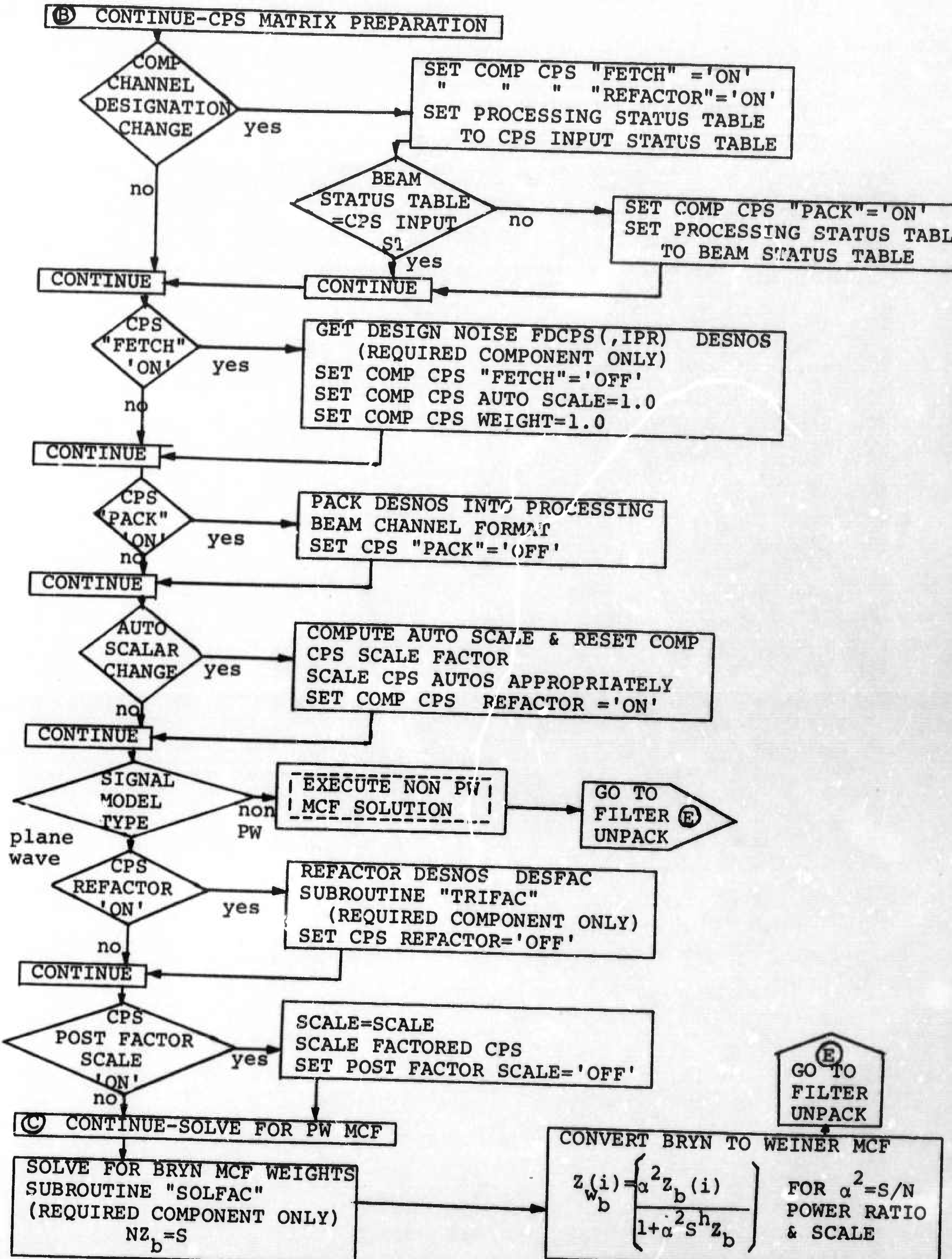


FIGURE III-5 MCFGEN
FILTER DESIGN PART B

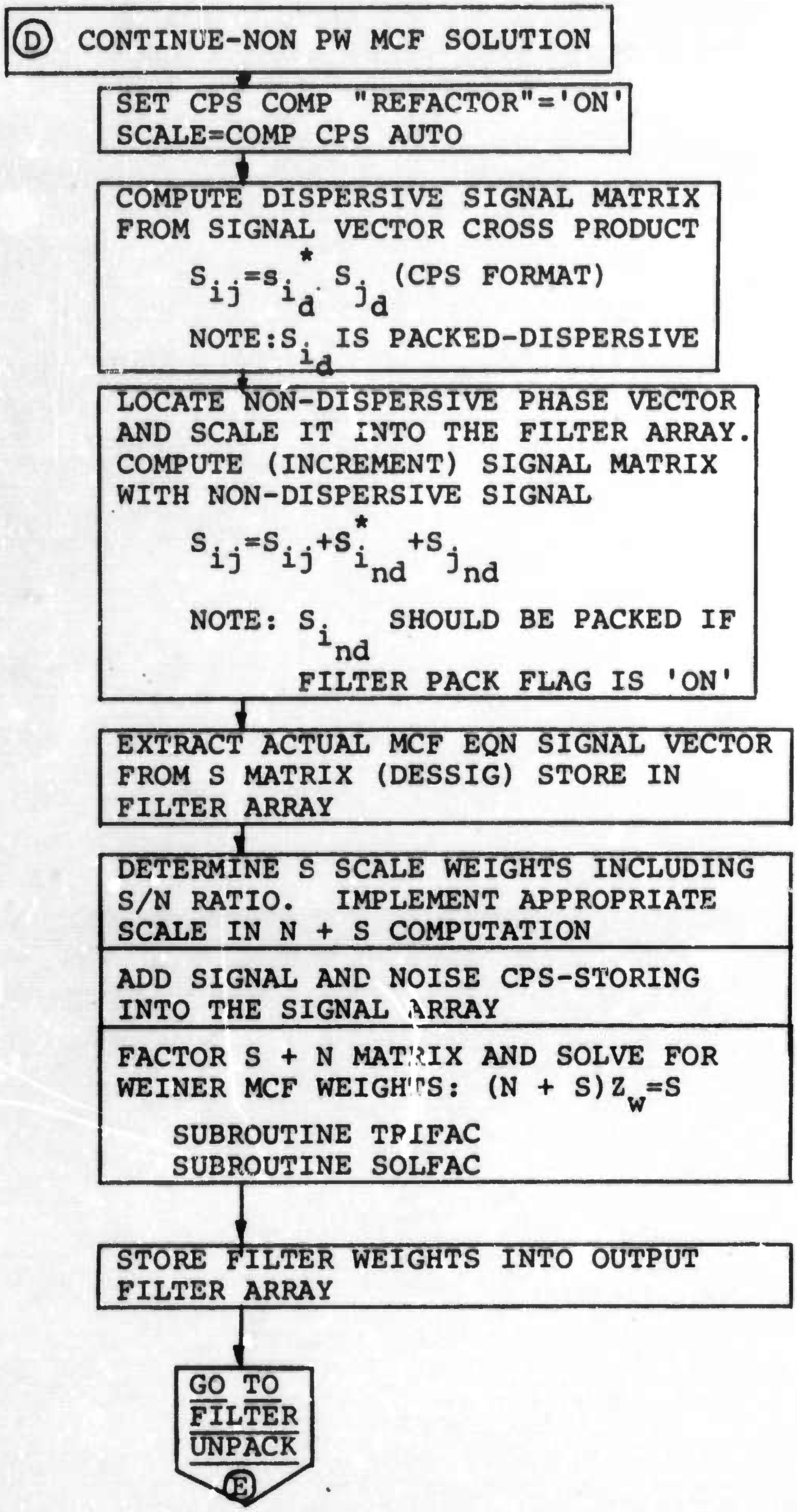


FIGURE III MCFGEN
FILTER DESIGN PART C

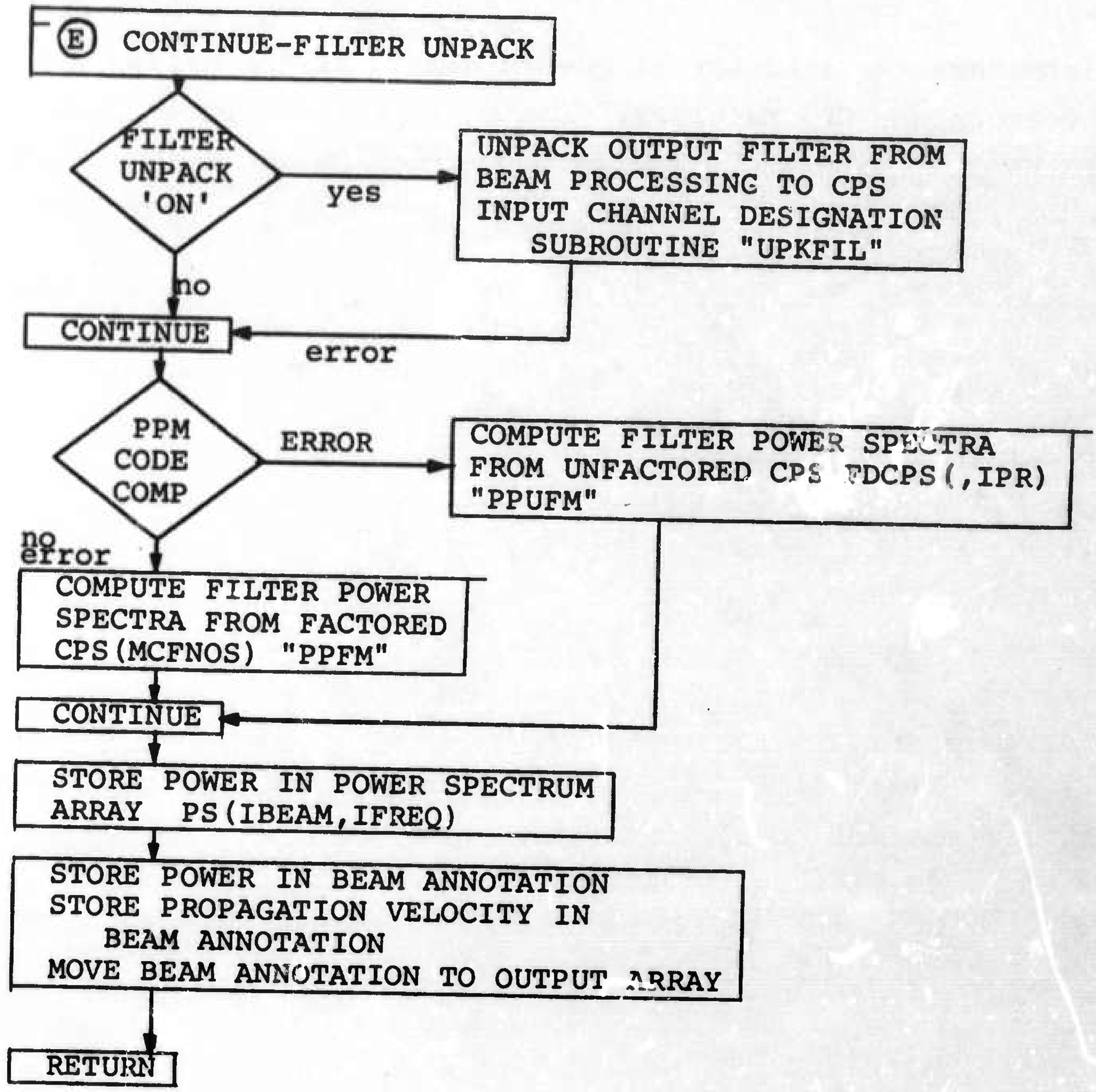


FIGURE III-5 MCFGEN
FILTER DESIGN PART D

The parameters required for frequency domain filter design are phase vectors and CPS matrices. Let $\hat{x}_j$ represent sensor location J, and let $\hat{K}$ be the plane wave propagation vector. The output of sensor j due to the plane wave signal of propagation vector $\hat{K}$ at frequency f is:

$$V_j = \exp[-i2\pi\hat{K}\cdot\hat{x}_j]$$

The collection of V_j for all sites of an array is called the phase vector for $\hat{K}$. If $\hat{K}$ is dispersive, where the phase velocity is c(f), then:

$$\hat{K} = [\frac{f}{c(f)}]\hat{1}_k$$

where 1_k is a unit vector in the direction of plane wave propagation $\hat{K}$. Note that the phase vector is a function of frequency, propagation mode, dispersion, and azimuth can be expanded into its complex trigonometric form:

$$V_j = \cos(2\pi\frac{f}{c(f)}\hat{1}_k\cdot\hat{x}_j) - i\sin(2\pi\frac{f}{c(f)}\hat{1}_k\cdot\hat{x}_j).$$

In terms of the plane vector, the frequency domain beam steer filters for sensor j of an array of NCHAN sensors for plane wave $\hat{K}$ are:

$$B_j(f) = \frac{1}{NCHAN}\overline{V_j(f)}$$

where the bar denotes complex conjugate. The plane wave signal model vector can also be represented in terms of $V_j(f)$:

$$S_j(f) = A(f)V_j(f)$$

where A(f) is an amplitude weighting factor.

For a set of transforms for NSEG segments of time data, the transform at frequency f, segment m and channel i is represented.

by $X_i^m(f)$. Then the measured noise cross-power spectral matrix N at frequency f is defined as:

$$N_{ij}(f)=\frac{1}{NSEG}\sum_{m=1}^{NSEG} \overline{X_i^m(f)}X_j^m(f)$$

The theoretical signal model CPS matrix S is defined as:

$$S_{ij}(f)=\overline{S_i(f)}S_j(f)$$

where $S_i(f)$ is the output of sensor i at frequency f due to the signal of wave-number $\hat{K}$. Note that:

$$\begin{aligned} S_i(f)&=A(f)V_i(f)\\ &=A(f)\exp(-i2\pi\hat{K}\cdot\hat{x}_i)\\ &=A(f)[\cos(\frac{2\pi f}{c(f)}\hat{1}_k\cdot\hat{x}_i)-i\sin(\frac{2\pi f}{c(f)}\hat{1}_k\cdot\hat{x}_i)] \end{aligned}$$

where $i=\sqrt{-1}$ and $\hat{1}_k$ is the unit vector in the direction of propagation $\hat{K}$.

The equation for the Wiener filter set Z to extract this signal from the noise with minimum mean square error is:

$$(N+S)Z=S_{jr}$$

where S_{jr} is the reference sensor column of the signal matrix.

The power spectra of processed noise may be obtained from the measured noise N, and the filter set Z by the equation:

$$P(f)=Z(f)^H N(f)Z(f)$$

where H indicates conjugate transpose, since

$$P(f)=\frac{1}{NSEG}\sum_{m=1}^{NSEG}\left|\sum_{i=1}^{NCHAN} Z_i X_i^m\right|^2$$

Whenever possible, MCFGEN programming takes computational advantage of special properties of matrices such as the CPS hermetian symmetry, and plane wave signal CPS. Computational advantage is also taken when working with non-dispersive phase vectors. Specifically, incrementing phase vectors between adjacent frequencies involves less computation than computing the phase vector for a particular frequency. Note that for frequency increment Δf:

$$V_j(f+\Delta f)=(V_j(f))(V_j(\Delta f))$$

since

$$\exp[-i\frac{2\pi(f+\Delta f)}{vel}\ \hat{1}_k\cdot\hat{x}_j]=\exp[-i\frac{2\pi f}{vel}\hat{1}_k\cdot\hat{x}_j]\ \exp[-i\frac{2\pi\Delta f}{vel}1_k\cdot\hat{x}_j]$$

2. Time Domain Filter Application

The primary function of TDFILT is to apply previously designed frequency domain filters, from the MCFGEN package, to the edited signal data, from the QCEDIT package. The filter application is performed in the time domain, which necessitates preparation of the filters and time domain data. Also, the time traces may be displayed. The basic processing flow for this program is shown in Figure III-6.

In the program flow, the first major task, Figure III-7, is the initialization of the event processing parameters, positioning of input tapes and the listing of input header arrays. Input parameters defined are:

- Processing default parameters
- Segment limits on modes of propagation
- Signal primary beam direction for signal component rotation
- Processing site status configuration
- Coordinate arrays packed to processing site status configuration

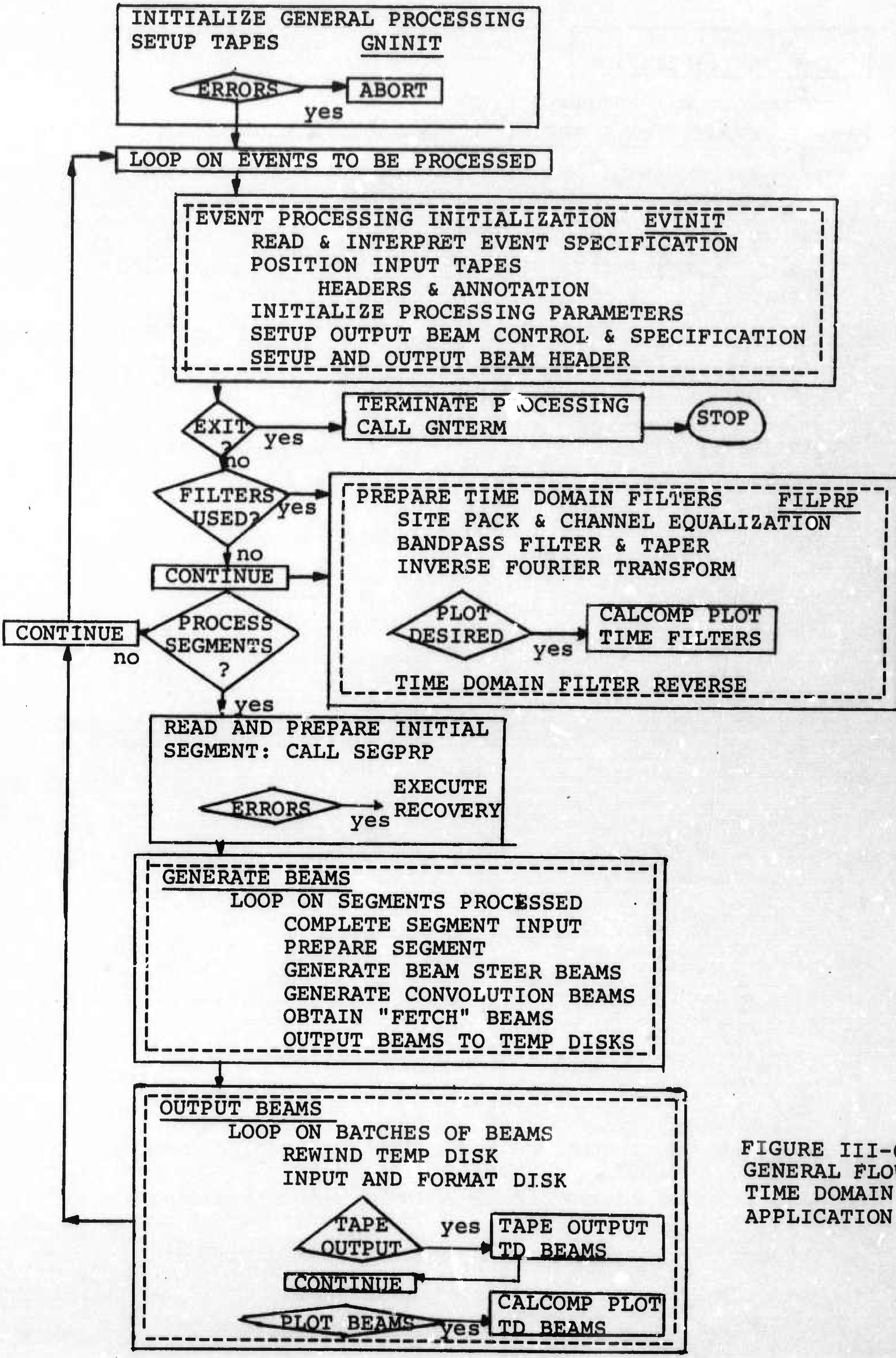


FIGURE III-6
GENERAL FLOW FOR
TIME DOMAIN FILTE
APPLICATION TDFI

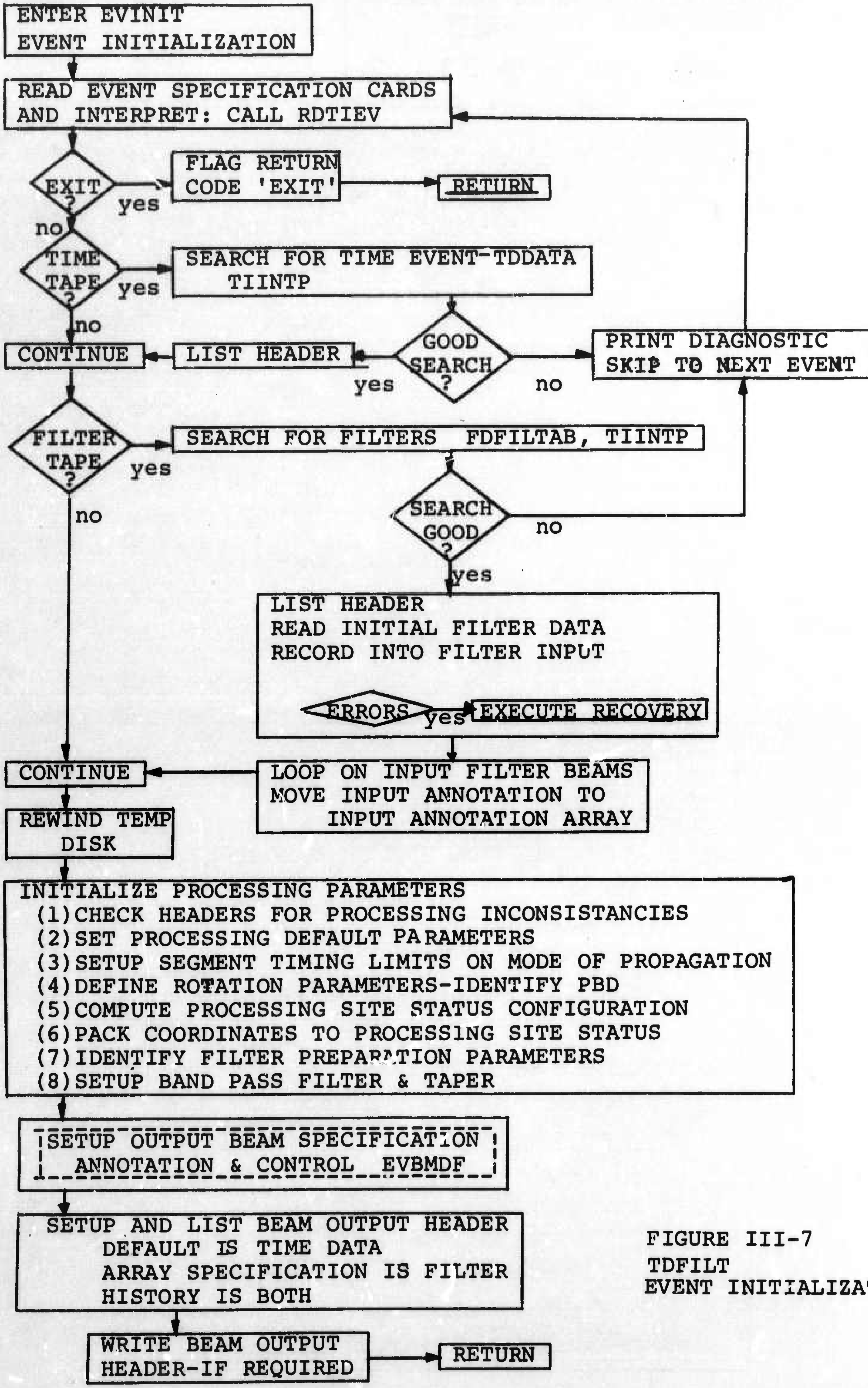


FIGURE III-7
TDFILT
EVENT INITIALIZATION

- Filter preparation parameters- a table of the input filters to be processed
- Calculation of a band pass filter and taper.

The task then calls subroutine EVBMDF, Figure III-8, to define the output beam specification annotation and control arrays. The annotation array is the beam description which is written on the output beam tape and is used in the output calcomp plot routine. The beam control array defines the necessary parameters for the beam generation subroutine and includes:

- Processing option-convolution, beam steer, site fetch
- Processing component
- Initial output point index-for convolution, the location of time zero in the time domain filter, and for beam steer, the output point index of the reference site
- Initial and final segment indexes to process
- Number of sites to process
- Number of filter points for convolution or time delays for beam steer.

The next major program section is the preparation of the input filters, FILPRP, as shown in Figure III-9. In this section the filters are prepared for time domain convolution as follows:

- If needed, channel equalize the filter points using the channel equalization weights from the noise matrix generation package, NOISE. (Note, if the filters are not to be equalized, the channel equalization weights may be removed from the filter points)
- Pack the filter weights into the output processing site status configuration

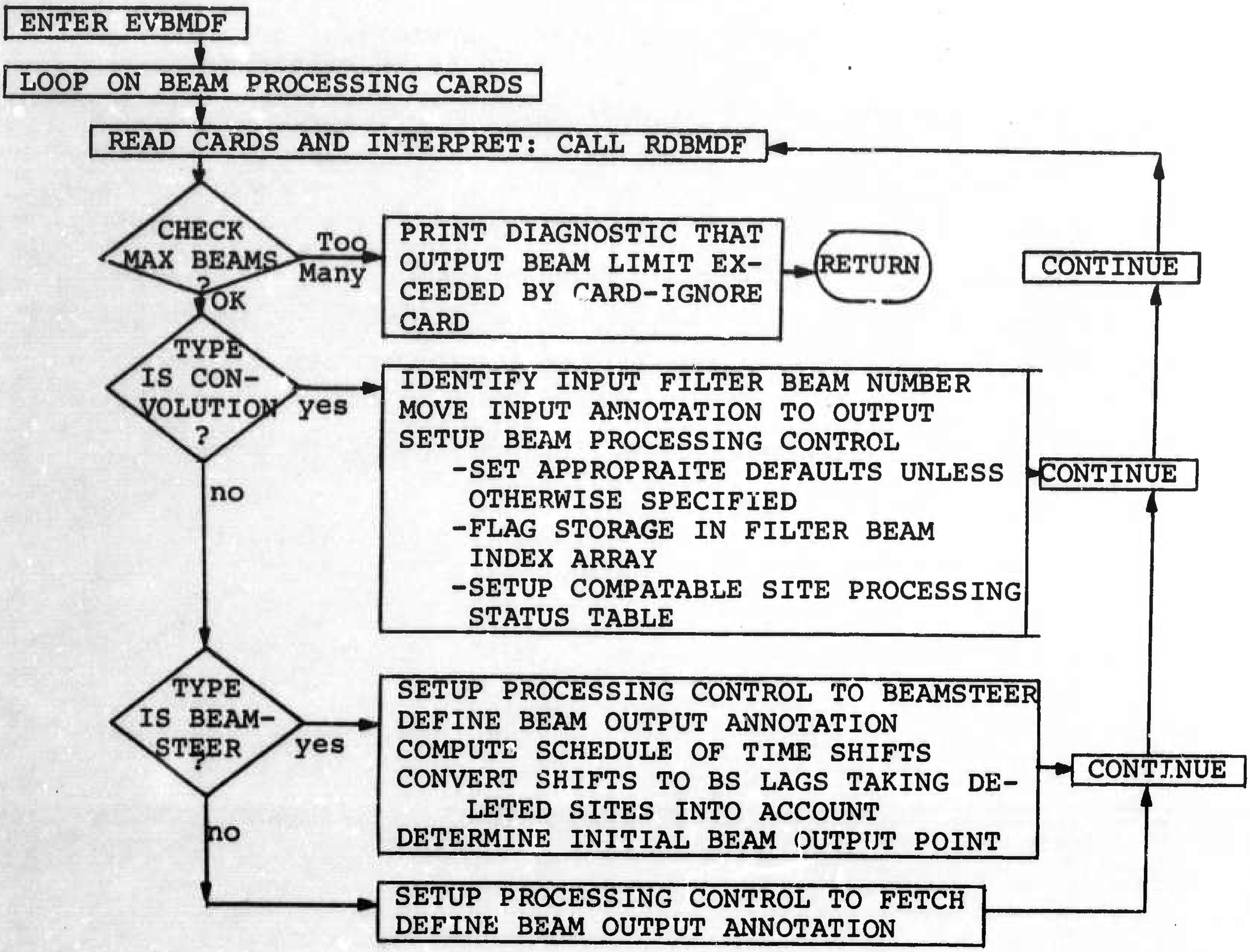


FIGURE III-8 TDFILT
SETUP OUTPUT BEAM CONTROL

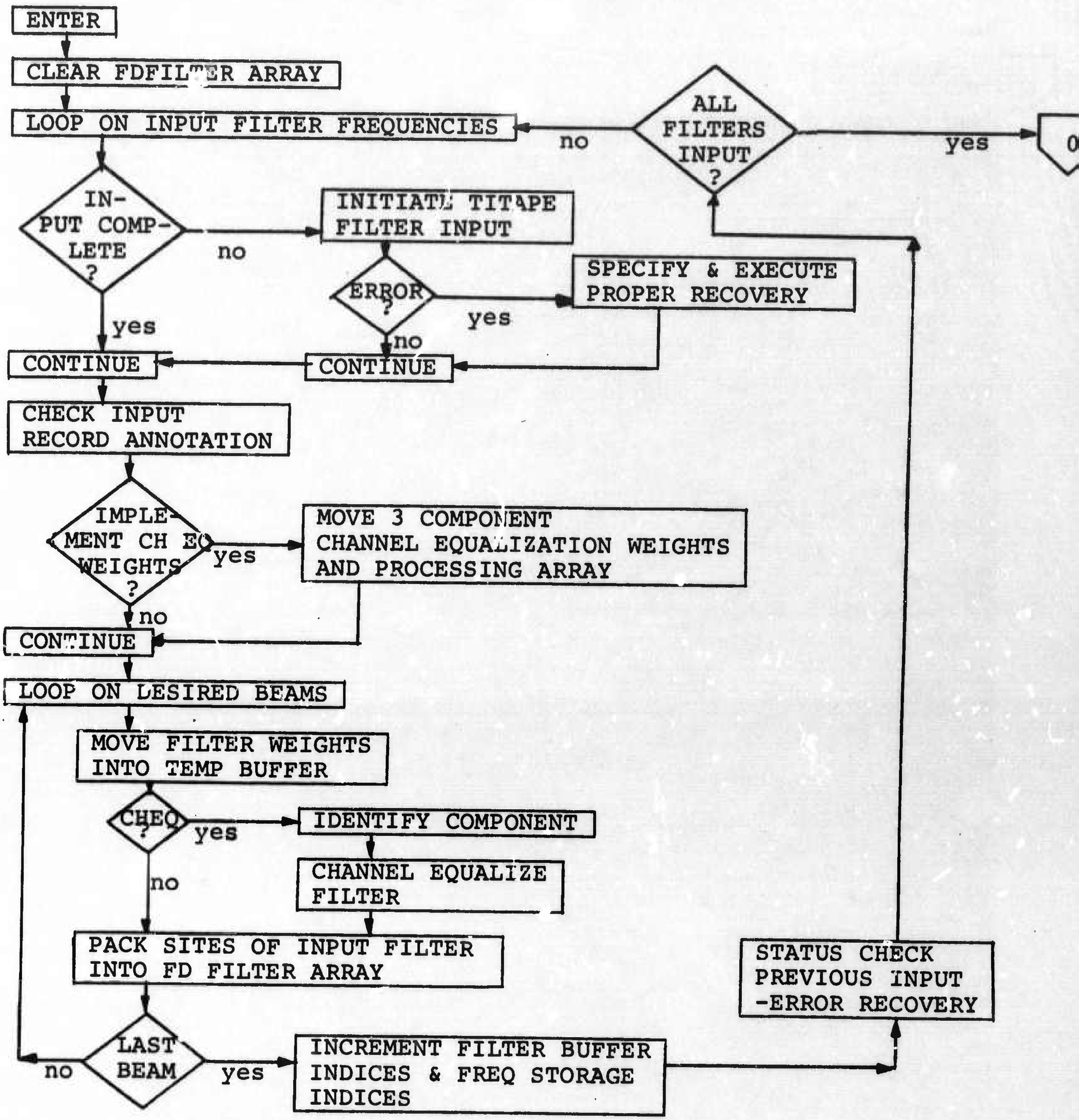


FIGURE III-9 TDFILT
FILTER PREPARATION

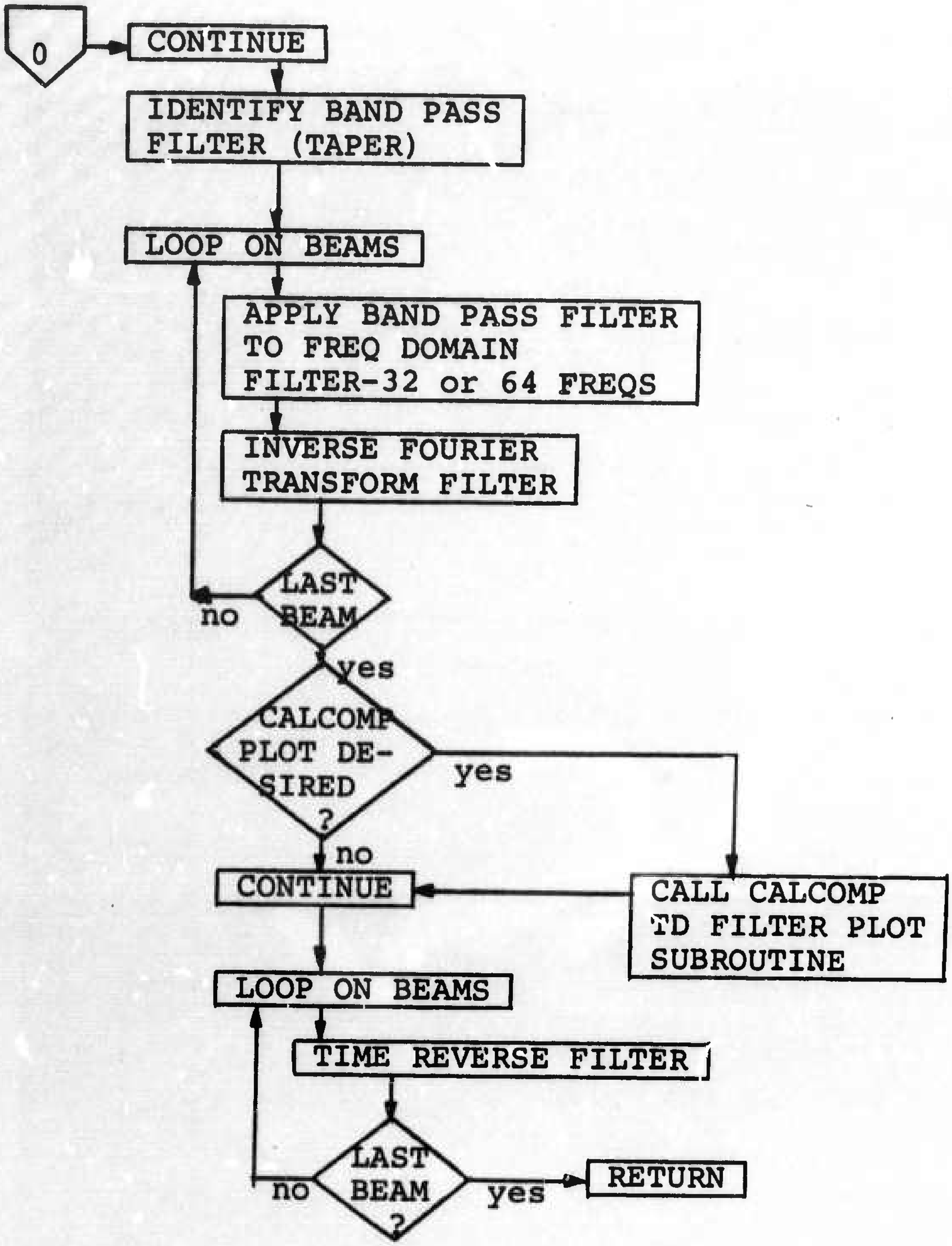


FIGURE III-9 (continued)

- Apply the previously designed band pass filter
- Inverse transform the filter points using an inverse Coolie-Tukey subroutine
- Calcomp plot the time domain impulse responses if desired
- Time reverse the time domain filter weights to prepare for convolution.

The next program section is the output beam generation, BEMGEN, as shown in Figure III-10. Program flow in this subroutine is over a loop on input data segments. Initial loop action is the time domain data preparation as follows:

- Pack the input data from QCEDIT format to the output processing site configuration
- Remove channel means from the data (means are calculated in QCEDIT package)
- Scale desired components by input scale factors
- Rotate the triax data to a coordinate system vertical,in-line and transverse to the primary beam direction
- Demultiplex data into the signal processing array.

The prepared signal is then either convolved with the appropriate filter, beam steered in a specified direction, or a specified trace is fetched from the data. After convolution and beam steering, the output trace is then positioned in the output beam array starting at the point calculated in the beam processing array specification. This action is then repeated for all specified filter convolutions, beam steers, and trace fetches. The beam output array is then stored on a temporary disk file, and the beam and signal buffers are positioned to prepare for the next input segment.

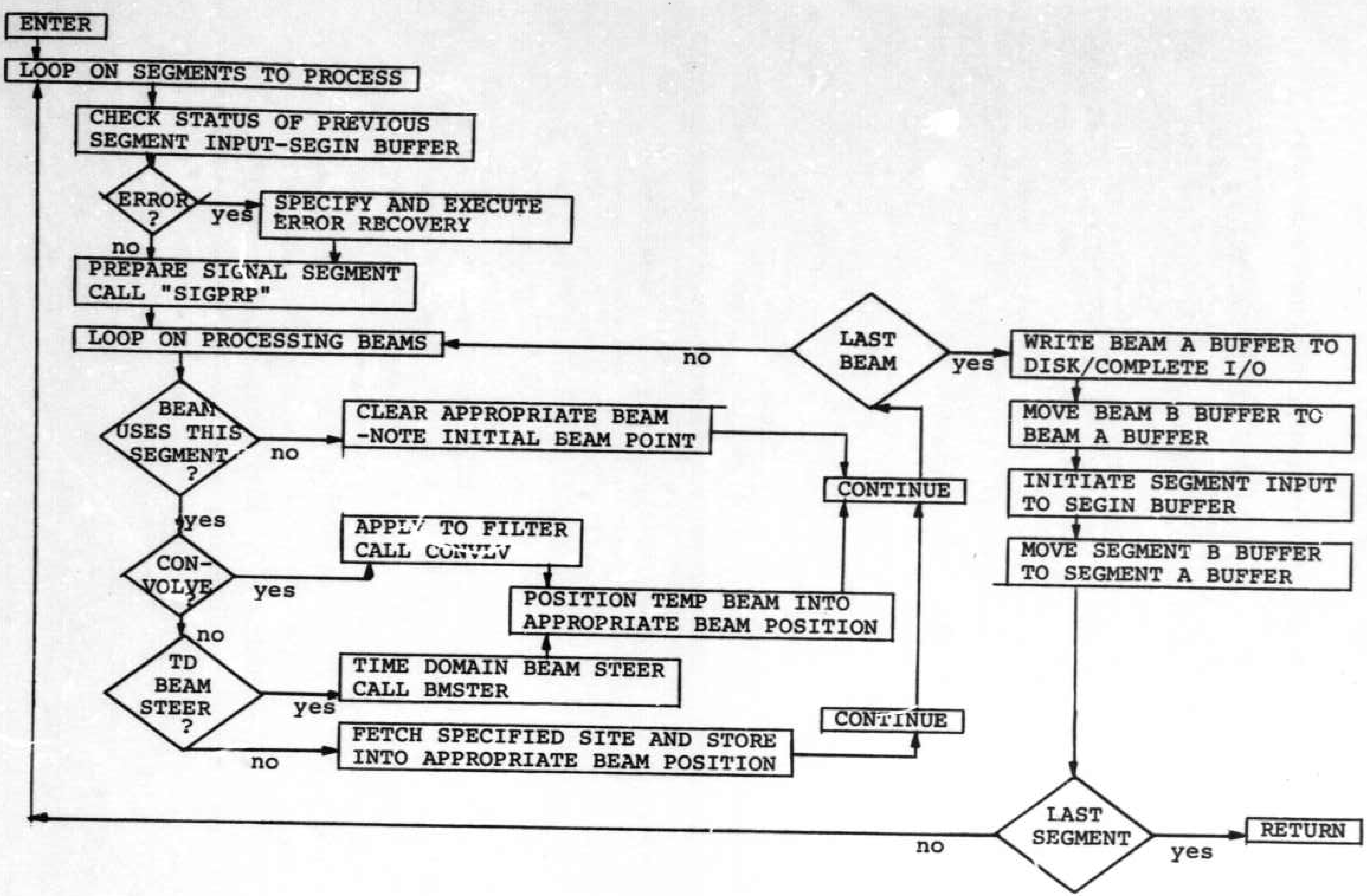


FIGURE III-10 TDFILT BEAM GENERATION

The last function of the program is to read the output beams from the temporary disk file, write them on an output tape for future analysis, and calcomp plot the beams and their annotation if specified.

3. Beam Analysis

The processing of time domain beams is handled by the program BEAMAN, the primary functions being spectral and discrimination analysis. BEAMAN basic flow is shown in Figure III-11; the input tape format is TDBEAM.

An input time domain beam, which may be the result of MCF or BS filtering, is partitioned based upon the specified propagation mode. The resultant partition is then Fourier transformed in preparation for spectral analysis. The frequency domain beam may be matched filtered with a reference waveform associated with the seismic region of interest. A tapered band pass filter may also be applied to the beam. Upon the computation of a beam's power spectra, spectral comparisons may be made between the beam and the reference site. The computation of spectral ratios and the printer display of spectra is also available.

The cleaned up frequency domain beams may be inverse Fourier transformed and discrimination parameters computed. A plot of the time domain beams completes BEAMAN processing.

D. TAPE USAGE

The handling of bulk data requires much computer processing effort. In this light, comments on ALPA off-line tape I/O and tape formats are in order in this quarterly report.

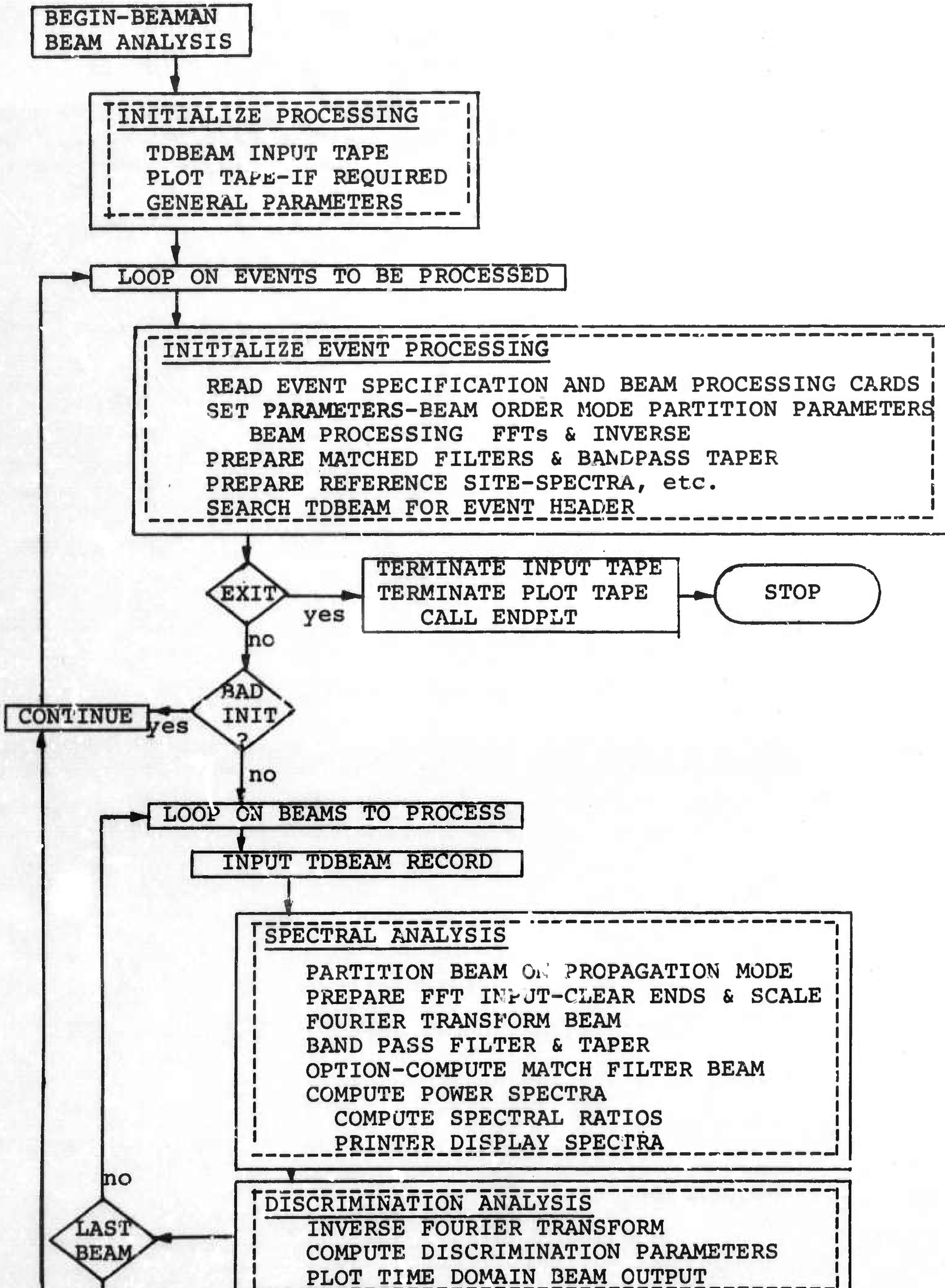
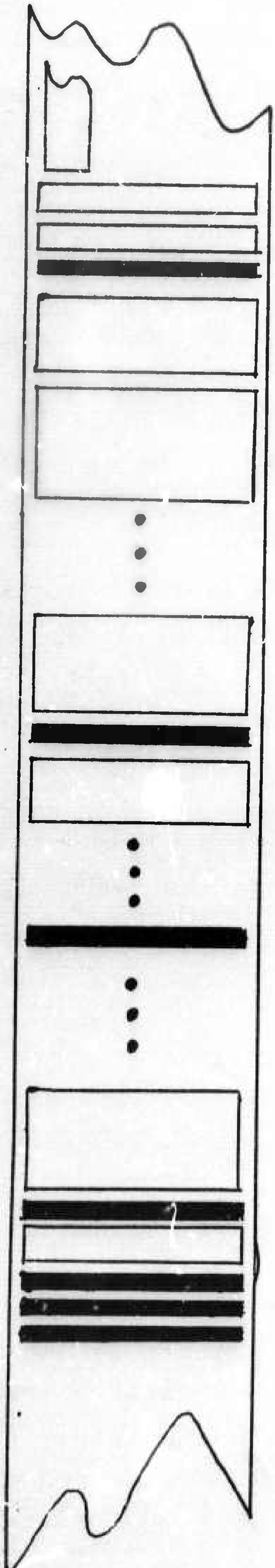


FIGURE III-11 BEAM ANALYSIS GENERAL FLOW

SAAC computer operations use IBM System/360 Disk Operating System, DOS. With DOS, the permanent data retention of a large volume of data is tape oriented. For this reason, ALPA off-line processing is basically tape oriented.

Much software effort has been expended in the development of tape I/O subroutines which optionally handle tapes; the subroutines are TITAPE and STATUS. The primary advantage of TITAPE and STATUS over the usual tape I/O packages is TITAPE's ability to overlap I/O and CPU activity. TITAPE initiates I/O commands while permitting the CPU to be available to the programmer during I/O command execution. Then whenever the programmer is ready for the completion of the previously initiated I/O command, STATUS waits until the command has been completed and returns I/O unit status to the programmer. In this fashion overlapped I/O and CPU processing is available to the programmer. Among the tape commands available are READ, WRITE, REWIND, UNLOAD, WRITE EOF, FORWARD SPACE FILE, and FORWARD SPACE RECORD. TITAPE also enables the programmer to communicate with the computer operator through the console typewriter. Among the STATUS codes returned after I/O are: parity error, EOF encountered, unit down, and end of tape.

The physical format of off-line processing tapes is shown in Figure III-12. One important objective of this general format is to minimize tape search time - the multi-file feature of this format assists in accomplishing this end. In general, a single file begins with a header record which is followed by a sequence of data records. The information required to satisfy a tape search is stored in the header. Therefore during tape search, for each file all that is necessary is a single READ followed by a single FORWARD SPACE FILE. This action repeats each file until the search terminates. The elimination of READs for every record will represent a con-



LOAD POINT

VOL SER LABEL (80 BYTES)

BOI HEADER LABEL (80 BYTES)
EOF

TI HEADER EVENT I (1360 BYTES)

DATA EVENT I

EOF

TI HEADER EVENT I+1 (1360 BYTES)

EOF

LAST DATA RECORD EVENT I+J

EOF
EOI TRAILER LABLE (80 BYTES)

EOI

NOTE: THIS FORMAT UTILIZES MULTI-FILE REELS

FIGURE III-12
PHYSICAL FORMAT PROCESSING
TAPES OFF-LINE

siderable savings in tape search time.

Each file on tape begins with a header record. The fixed length header record contains the annotation and specific parameters associated with the data records which follow. This information can be broken into the following categories:

- Data format specification (80 bytes)
- Processing parameters (160 bytes)
- Event specification parameters (120 bytes)
- PDE annotation & comments (240 bytes)
- Array designation (560 bytes)
- Processing history (200 bytes).

Following the header record in each file is a sequence of data records. All of the data records in a particular file are of a specific format depending upon the contents of data stored. These basic formats are:

- TDDATA-time domain multichannel traces
- TDBEAM-time domain single channel traces
- FDDATA-frequency domain multi-channel Fourier transforms
- FDCPS-3C-frequency domain, three component cross-power spectrum matrix
- FDFILTAB-frequency domain filter weights with beam annotation
- FDPS-frequency domain single channel power spectra.

The categories cover the primary needs for large volume data storage. Note that the ALPA library tape is a special format and is defined primarily by on-line ALPA processing considerations.

E. STATUS

Off-line software efforts during the third quarter have been primarily directed toward the coding and debugging of major processing packages. Figure III-13 diagrams the software programs according to name and data dependence. As of this writing, programming efforts on the following programs have been completed: DMPLIB, LIBNAN (which can also be used for signal analysis-SIGNAN), DMPXXX, SELECT, QCEDIT, and NOISE. The coding has been completed and debugging is currently active on MCFGEN and TDFILT. Both coding and debugging efforts are required for the completion of EVPLOT, NOISAN and BEAMAN. Note that the signal enhancement portion of the off-line package can be used to separate overlapping events.

Programming of the main-line packages will be completed by the end of February and the entire off-line package will be completed by the end of March (including testing of the package components using ALPA data).

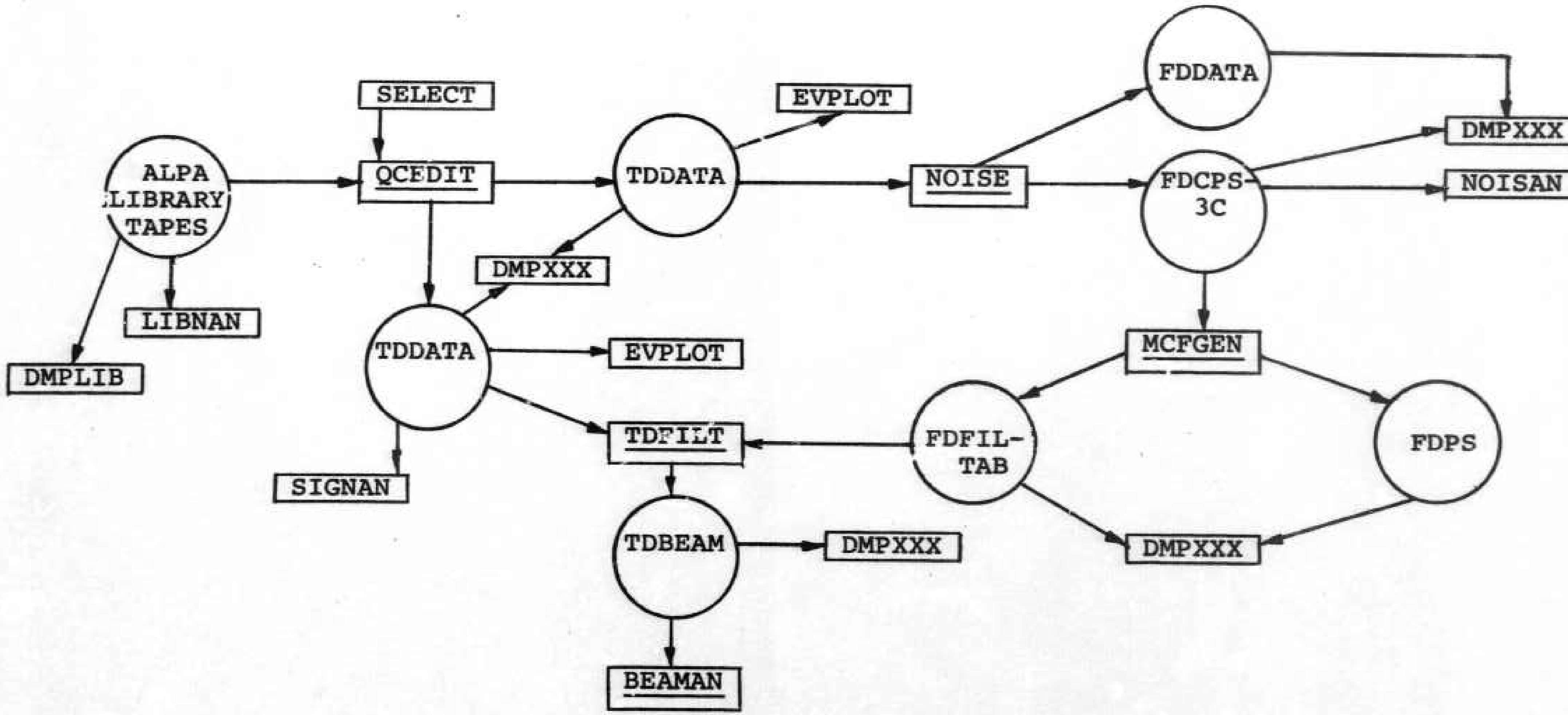


FIGURE III-13 OFF-LINE SOFTWARE PACKAGES BY DATA DEPENDENCE

SECTION IV
REFERENCES

1. Texas Instruments Incorporated, 1969: Long-Period Array Processing Development, Quarterly Report No. 1, Contract F 33657-69-C-1063, 8 August.

2. Texas Instruments Incorporated, 1969: Long-Period Array Processing Development, Quarterly Report No. 2, Contract F 33657-69-C-1063, 10 November.

APPENDIX A
CARD INPUT FOR
THE INITIALIZATION ROUTINE

The format of the initialization task is described below.

Card 1. Data Preparation Defloat Shift Card

Cols. 1-30 "DATA PREPARATION DEFLOAT SHIFT"

31-78 Blank

79-80 Defloat Shift (I format)

Card 2. Component Long-Term Averages Card

Cols. 1-18 "LONG-TERM AVERAGES"

19-30 Blank

31-40 Component 1 power long-term average (I format)

41-50 Blank

51-60 Component 2 power long-term average (I format)

61-70 Blank

71-80 Component 3 power long-term average (I format)

Card 3. Component Upper Tolerances Card

Cols. 1-16 "UPPER TOLERANCES"

17-30 Blank

31-40 Component 1 power upper tolerance (I format)

41-50 Blank

51-60 Component 2 power upper tolerance (I format)

61-70 Blank

71-80 Component 3 power upper tolerance (I format)

Card 4. **Component Lower Tolerances Card**

Cols. 1-16 "LOWER TOLERANCES"

17-29 Blank

30-40 Component 1 power lower tolerance (I format)

41-49 Blank

50-60 Component 2 power lower tolerance (I format)

61-69 Blank

70-80 Component 3 power lower tolerance (I format)

Card 5. **Component Long-Term-Average Startup Modifiers Card**

Cols. 1-21 "LTA STARTUP MODIFIERS"

22-25 Blank

26-40 Component 1 LTA startup modifier (E format)

41-45 Blank

46-60 Component 2 LTA startup modifier (E format)

61-65 Blank

66-80 Component 3 LTA startup modifier (E format)

Card 6. **Component Modified Time Constants Card**

Cols. 1-23 "MODIFIED TIME CONSTANTS"

24-25 Blank

26-40 Component 1 modified time constant (E format)

41-45 Blank

46-60 Component 2 modified time constant (E format)

61-65 Blank

66-80 Component 3 modified time constant (E format)

Card 7. **Time Constant Card**

Cols. 1-13 "TIME CONSTANT"

14-70 Blank

71-80 Time constant for long-term averages (E format)

Card 8. **Upper Tolerance Scale Factor Card**

Cols. 1-28 "UPPER TOLERANCE SCALE FACTOR"

29-70 Blank

71-80 Upper tolerance scale factor (E format)

Card 9. **Lower Tolerance Scale Factor Card**

Cols. 1-28 "LOWER TOLERANCE SCALE FACTOR"

29-70 Blank

71-80 Lower tolerance scale factor (E format)

Card 10. **Event Trigger Factor Card**

Cols. 1-20 "EVENT TRIGGER FACTOR"

21-70 Blank

71-80 Event trigger factor (E format)

Card 11. **Beam Scaling Constant Card**

Cols. 1-21 "BEAM SCALING CONSTANT"

22-64 Blank

65-80 Beam scaling constant (Z format)

Card 12. **Pre-Rotation Control Card**

Cols. 1-20 "PRE-ROTATION CONTROL"

21-79 Blank

80 Pre-rotation control parameter (I format)

0 = no pre-rotation

1 = incremental pre-rotation (to triax orientation)

(continued) 2 = radical pre-rotation (to V E, N orientation)

Card 13. <u>Pre-Rotation Shift Parameter Card</u>

Cols. 1-28 "PRE-ROTATION SHIFT PARAMETER"

29-78 Blank

79-80 Shift for pre-rotation CFIL microcode (Z format)

Cards 14-32. <u>Pre-Rotation Angles Cards (19)</u>

Cols. 1-25 "PRE-ROTATION ANGLES--SITE"

26 Blank

27-28 Site Number (I format)

29-30 Blank

31-40 Axis of rotation's angle from component 3 (E format)

41-50 Blank

51-60 Axis of rotation's angle counter-clockwise from component 1 about component 3 (E format)

61-70 Blank

71-80 Angular rotation (E format)

Card 33. <u>BBF Postshift Parameter Card</u>

Cols. 1-23 "BBF POSTSHIFT PARAMETER"

24-78 Blank

79-80 Shift parameter for BBF microcode (Z format)

Card 34. <u>Reference Location Coordinates Card</u>

Cols. 1-30 "REFERENCE LOCATION COORDINATES"

31-50 Blank

51-60 X-coordinate of reference location (E format)

61-70 Blank

(continued)	71-80	Y-coordinate of reference location (E format)

Cards 35-53. <u>Location Coordinates Cards (19)</u>

Cols.	1-26	"LOCATION COORDINATES--SITE"
	27	Blank
	28-29	Site Number (I format)
	30-50	Blank
	51-60	X-coordinate of site (E format)
	61-70	Blank
	71-80	Y-coordinate of site (E format)

Cards 54-63. <u>Velocity and Azimuth Cards (10)</u>

Cols.	1-26	"VELOCITY AND AZIMUTH--BEAM"
	27	Blank
	28-29	Beam number (I format)
	30-50	Blank
	51-60	Velocity of beam (E format)
	61-70	Blank
	71-80	Azimuth of beam (look direction) (E format)

Card 64. <u>Post-Rotation Shift Parameter Card</u>

Cols.	1-29	"POST-ROTATION SHIFT PARAMETER"
	30-78	Blank
	79-80	Shift parameter for post-rotation CFIL microcode (Z format)

Cards 65-84. <u>SAAC Trace Entry Cards (20)</u>

Cols.	1-23	"ENTRIES FOR SAAC TRACE"
	24	Blank
	25-26	SAAC trace number (I format)
	27-35	Blank
	36-40	Method of formation (I format)

(Continued) 41-55 Blank

56-60 Site or beam number (I format)

61-75 Blank

76-80 Component number (I format)

Card 85. Channel Rotation Shift Parameter Card

Cols. 1-32 "CHANNEL ROTATION SHIFT PARAMETER"

33-78 Blank

79-80 Shift parameter for CFIL microcode used in forming develocorder traces (Z format)

Card 86. Calibration Card

Cols. 1-3 "CAL"

4-5 Blank

6-80 15 points of calibration trace (format 15I5)

Card 87. Develocorder Shift Card

Cols. 1-18 "DEVELOCORDER SHIFT"

19-79 Blank

80 Develocorder shift (I format)

Card 88. Prior Tape Volume Number Card

Cols. 1-29 "VOLUME NUMBER FROM PRIOR TAPE"

30-74 Blank

75-80 Volume number from prior tape (A format)

APPENDIX B

ON-LINE TYPEWRITER INPUT
FOR THE UPDATE SUBTASK

The format of the update subtask messages is described below. The fundamental unit of processing in the update subtask is a field, which is defined to be any string of contiguous non-blank characters. There are three valid commands: UPDATE, TAPECHANGE, and STOP. One of these three commands must be in the first field of the message. When UPDATE is specified, it must be followed by a valid update code (any letter from A to T), an asterisk, an identifier corresponding to the update code, and the data to be inserted into the on-line package. When TAPECHANGE is the update message, the unit switch bit in the frame processor is turned on and the frame processor closes the current ALPA library tape. All new data is then written on an alternate tape unit. When STOP is supplied as an update message, the program is terminated and a core dump is printed.

Tape Change Message

Field 1	"TAPECHANGE"

Stop Message

Field 1	"STOP"

Data Preparation Defloat Shift Update Message

Field 1	"UPDATE"
Field 2	"A"
Field 3	"*"
Field 4	"DEFLOATSHIFT"
Field 5	Defloat shift (I format)

Long-Term Average Update Message

Field 1	"UPDATE"
Field 2	"B"
Field 3	"*"
Field 4	"LTA"
Field 5	Component number (I format) or "X" (signifying all three components)
Field 6	Power long-term average (I format)

Long-Term-Average Startup Modifier Update Message

Field 1	"UPDATE"
Field 2	"C"
Field 3	"*"
Field 4	"STARTUP"
Field 5	Component number (I format) or "X" (signifying all three components)
Field 6	LTA startup modifier (E format)

Time Constant Update Message

Field 1	"UPDATE"
Field 2	"D"
Field 3	"*"
Field 4	"TIMCONST"
Field 5	Time constant for long-term averages (E format)

Upper Tolerance Scale Factor Update Message

Field 1	"UPDATE"
Field 2	"E"
Field 3	"*"
Field 4	"UPPERSCL"
Field 5	Upper tolerance scale factor (E format)

Lower Tolerance Scale Factor Update Message

Field 1	"UPDATE"
Field 2	"F"
Field 3	"*"
Field 4	"LOWERSCL"
Field 5	Lower tolerance scale factor (E format)

Event Trigger Factor Update Message

Field 1	"UPDATE"
Field 2	"G"
Field 3	"*"
Field 4	"EVENTTRG"
Field 5	Event trigger factor (E format)

Beam Scaling Constant Update Message

Field 1	"UPDATE"
Field 2	"H"
Field 3	"*"
Field 4	"SCALECON"
Field 5	Beam scaling constant (Z format, 16 Characters)

Pre-Rotation Control Update Message

Field 1	"UPDATE"
Field 2	"I"
Field 3	"*"
Field 4	"ROTCNTRL"
Field 5	Pre-rotation control parameter (I format) 0 = no pre-rotation 1 = incremental pre-rotation (to triax orientation) 2 = radical pre-rotation (to V, E, N orientation)

Pre-Rotation Shift Parameter Update Message

Field 1	"UPDATE"
Field 2	"J"
Field 3	"*"
Field 4	"PROTSHIFT"
Field 5	Shift for pre-rotation CFIL microcode (Z format, 2 characters)

Pre-Rotation Angles Update Message

Field 1	"UPDATE"
Field 2	"K"
Field 3	"*"
Field 4	"PROTANGLES"
Field 5	Site number (I format)
Field 6	Axis of rotation's angle from component 3 (E format)
Field 7	Axis of rotation's angle counterclockwise from component 1 about component 3 (E format)
Field 8	Angular rotation (E format)

BBF Postshift Parameter Update Message

Field 1	"UPDATE"
Field 2	"L"
Field 3	"*"
Field 4	"BBFSHIFT"
Field 5	Shift parameter for BBF microcode (Z format, 2 characters)

Reference Location Coordinates Update Message

Field 1	"UPDATE"
Field 2	"M"
Field 3	"*"
Field 4	"REFLOC"
Field 5	X-coordinate of reference location (E format)

(continued) Field 6 Y-coordinate of reference location (E format)

<u>Location Coordinates Update Message</u>

Field 1	"UPDATE"
Field 2	"N"
Field 3	"*"
Field 4	"LOC"
Field 5	Site number (I format)
Field 6	X-coordinate of site (E format)
Field 7	Y-coordinate of site (E format)

<u>Velocity and Azimuth Update Message</u>

Field 1	"UPDATE"
Field 2	"O"
Field 3	"*"
Field 4	"VELAZBM"
Field 5	Beam number (I format)
Field 6	Velocity of beam (E format)
Field 7	Azimuth of beam (look direction) (E format)

<u>Post-Rotation Shift Parameter Update Message</u>

Field 1	"UPDATE"
Field 2	"P"
Field 3	"*"
Field 4	"BMROTSHIFT"
Field 5	Shift parameter for post-rotation CFIL microcode (Z format, 2 characters)

<u>SAAC Trace Entry Update Message</u>

Field 1	"UPDATE"

(continued)

Field 2	"Q"
Field 3	"*"
Field 4	"SAACTRACE"
Field 5	SAAC trace number (I format)
Field 6	Method of formation (I format)
Field 7	Site or beam number (I format)
Field 8	Component number (I format)

Channel Rotation Shift Parameter Update Message

Field 1	"UPDATE"
Field 2	"R"
Field 3	"*"
Field 4	"CHANROTSHIFT"
Field 5	Shift parameter for CFIL microcode used in forming develocorder traces (Z format, 2 characters)

Calibration Update Message

Field 1	"UPDATE"
Field 2	"S"
Field 3	"*"
Field 4	"CAL"
Fields 5-19	Calibration trace points (I format)

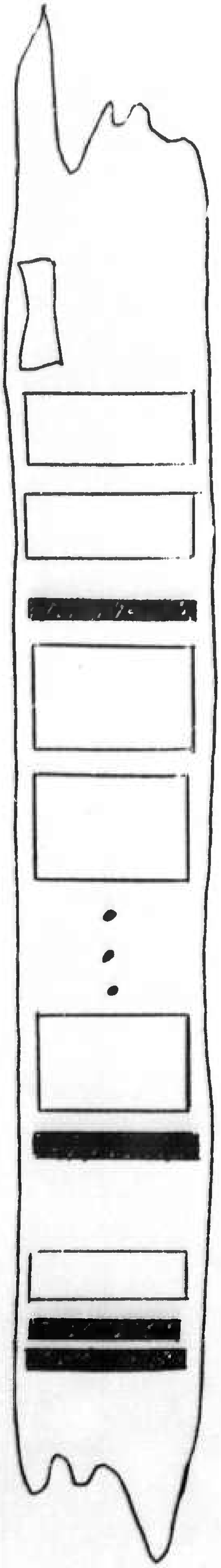
Develocorder Shift Update Message

Field 1	"UPDATE"
Field 2	"T"
Field 3	"*"
Field 4	"DEVELOSHIFT"
Field 5	Develocorder shift (Z format, 2 Characters)

APPENDIX C
ALPA LIBRARY TAPE FORMAT

This appendix presents a current version of the ALPA Library tape format. Changes from the TI memo of 1 December 1969 to AFTAC are indicated by a C in the left hand margin. A section detailing the time relationships among the raw data, beams and status information in a given record is included.

TAPE FORMAT



LOAD POINT

VOL-SERIAL HEADER RECORD (80 BYTES)

HEADER LABEL (80 BYTES)

END OF FILE (TAPE MARK)

DATA RECORD #1 (3042 BYTES)

DATA RECORD #2 (3042 BYTES)

DATA RECORD # NREC (3042 BYTES)

END OF FILE (TAPE MARK)

TRAILER LABEL (80 BYTES)

END OF FILE (TAPE MARK)
END OF FILE (TAPE MARK)

DATA RECORD FORMAT

'AL'	BYTES	0-1
DATA FRAME #1	BYTES	2-191
DATA FRAME #2	BYTES	192-381
∘ ∘ ∘	BYTES	382...2471
DATA FRAME #14	BYTES	2472-2661
DATA FRAME #15	BYTES	2662-2851
STATUS FRAME	BYTES	2852-3041

TOTAL RECORD LENGTH = 3042 BYTES
FRAME LENGTH = 190 BYTES

VOL-SERIAL HEADER

BYTES	0-3	HEADER IDENTIFIER	'VOL1'
BYTES	4-9	VOL-SERIAL	e.g. 'T00013'
BYTE	10	SECURITY INDICATOR	'1'
BYTES	11-79	RESERVED FOR EXPANSION	'b...b'

TOTAL LENGTH IS 80 BYTES

NOTE: All data in this record should be interpreted as alphanumeric. 'VOL1' and '1' are fixed. The '1' actually implies a permanent retention cycle. The VOL-SERIAL represents the tape number. The first of six characters is alphabetic and is 'T', for TI. The remaining five characters provide the 'T'-SERIES TAPE number.

HEADER LABEL

BYTES	0-3	IDENTIFIER	'HDR1'
BYTES	4-14	TAPE TYPE	'LOWbRATEbbb'
BYTES	15-20	LOCATION	'WAPSbb'
BYTES	21-26	VOL-SERIAL (THIS TAPE)	e.g. 'T00056'
BYTES	27-28	RESERVED	'bb'
BYTES	29-34	VOL-SERIAL (PREVIOUS TAPE)	e.g. 'T00055'
BYTES	35-36	LOCATION CODE	'02' (SAAC)
BYTES	37-38	TAPE TYPE CODE	'14' (LOW RATE)
BYTES	39-40	TAPE FORMAT VERSION	'01'
BYTES	41-46	DATE = 'bYRDAY'	e.g. 'b70181'
BYTES	47-52	RECYCLE DATE	'b99365'
BYTE	53	RETENTION CODE	'1' (PERMANENT)
BYTES	54-59	DATE = 'bYRDAY'	SAME AS BYTES 41-46
BYTES	60-65	PROCESSING SYSTEM	'IISPSb'
BYTES	66-79	COMMENTS	'TIbALPAbLPDATA'

TOTAL LENGTH IS 80 BYTES
NOTE: All data in this record should be interpreted as alphanumeric characters.

TRAILER LABEL

BYTES	0-3	IDENTIFIER	'EOF1'
BYTES	4-28	RESERVED	'bb...bb'
BYTES	29-34	VOL SERIAL (NEXT TAPE)	e.g. 'T00057'
BYTES	35-79	RESERVED	'bb...bb'

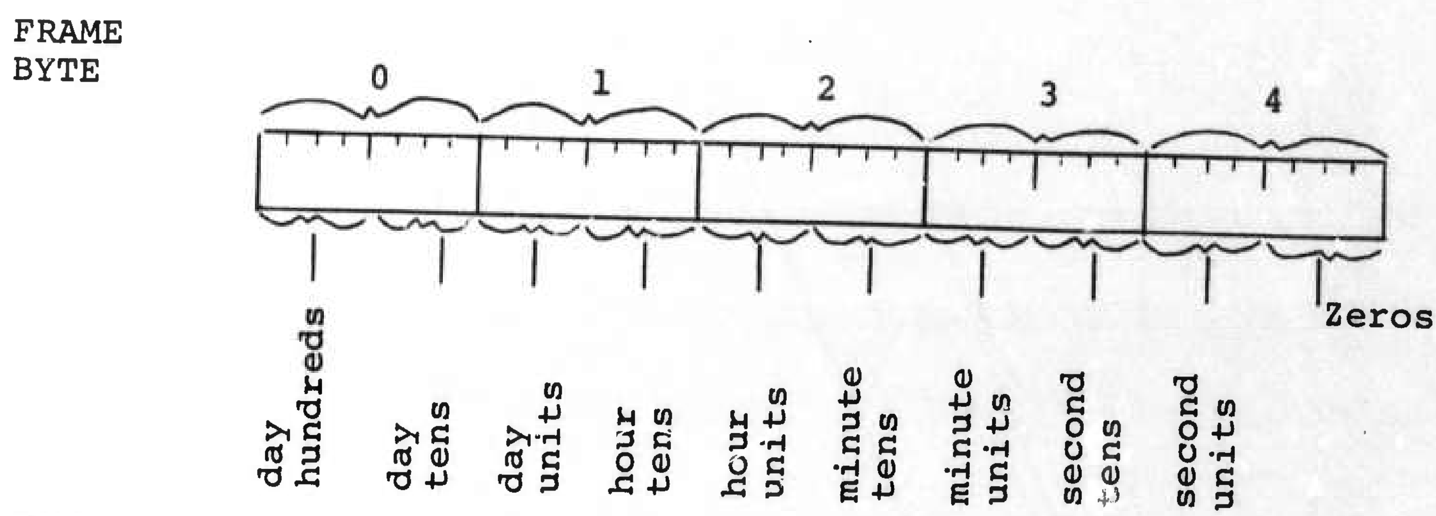
TOTAL LENGTH IS 80 BYTES

DATA FRAME FORMAT

LENGTH		POSITION
5 BYTES	RAW TIMING WORD	0-4
3 BYTES	RAW SITE ERROR TABLE	5-7
10 BYTES	RAW SEIS FUNCTION TABLE	8-17
114 BYTES	RAW LONG PERIOD DATA	18-131
56 BYTES	BEAM STEER DATA	132-187
2 BYTES	FRAME FLAG BYTES	188-189

TOTAL LENGTH IS 190 BYTES

RAW TIMING WORD (5 BYTES 0-4)

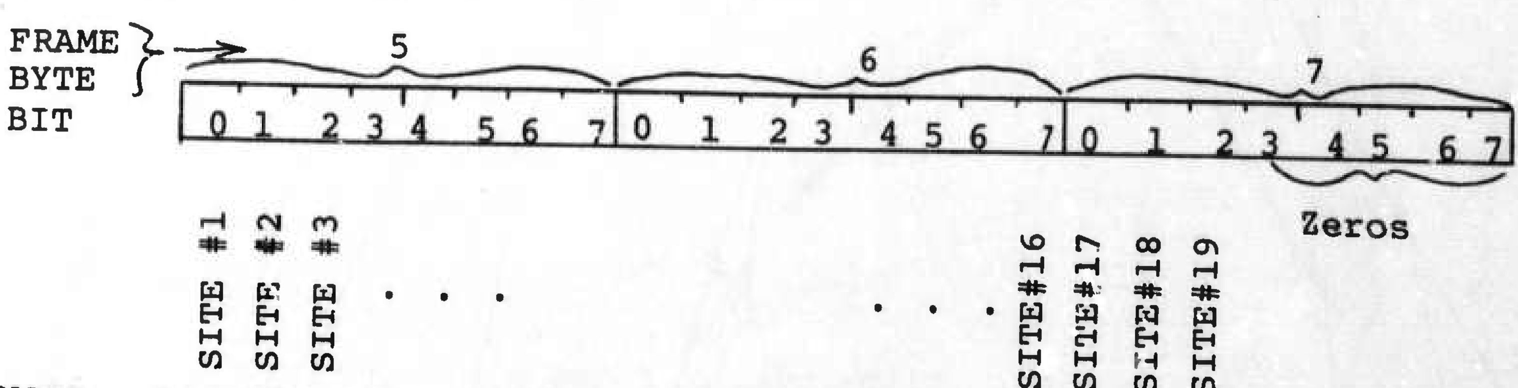


NOTE: Digits in timing word are single HEX digit-BCD

e.g. $0010_2=2_{10}=2_{16}$
$1001_2=9_{10}=9_{16}$

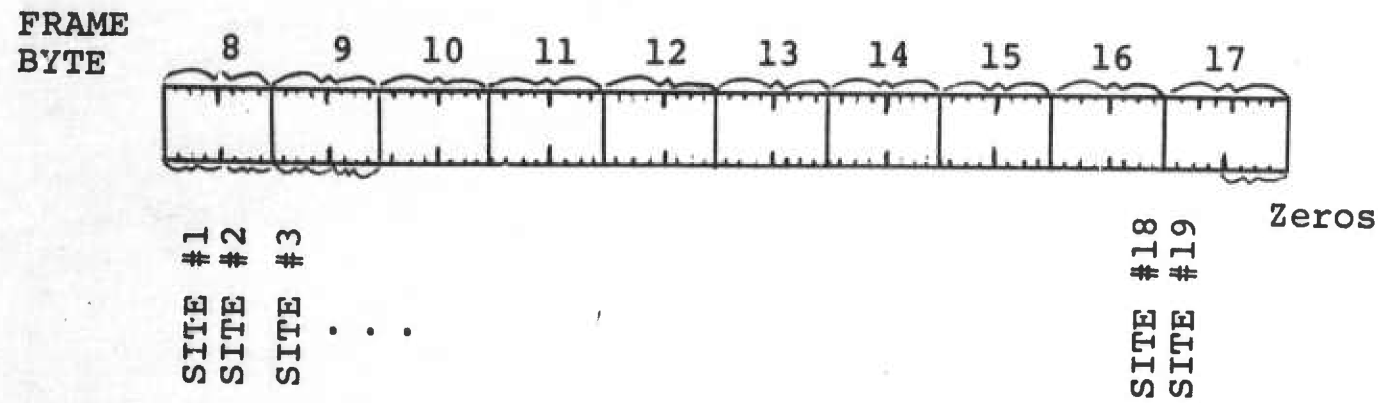
HEX characters A th.. F are illegal

RAW SITE ERROR TABLE (3 BYTES 5-7)



NOTE: One bit represents one site.
Bit Value =0⇒ normal Bit Value=1⇒ abnormal
This bit configuration is to be referred to as the SET format.

RAW SEISMOMETER FUNCTION TABLE (10 BYTES 8-17)



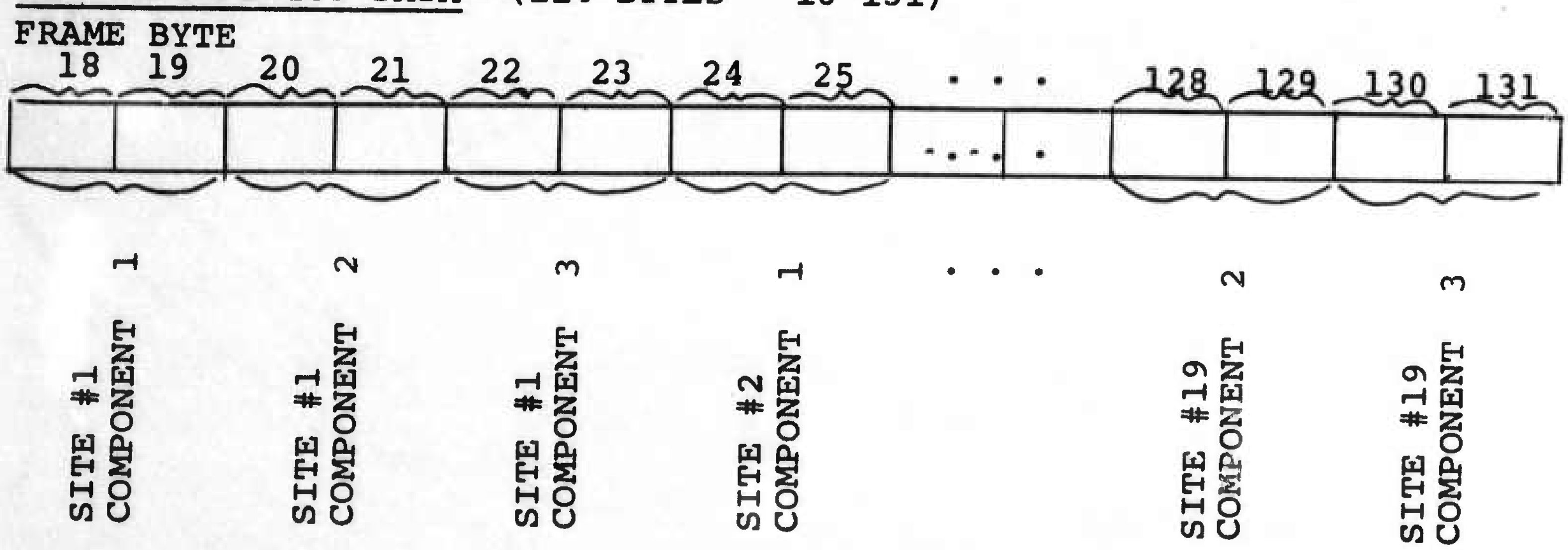
NOTE: Four bits represent one site-2 sites are represented in one byte.

Bit 0 or 4 corresponds to component 1
Bit 1 or 5 corresponds to component 2
Bit 2 or 6 corresponds to component 3
Bit 3 or 7 unused

Bit Value=0 ⇒ normal site/component
Bit Value=1 ⇒ abnormal site/component

NOTE: This configuration of bits will be denoted SFT format and will be referenced in the discussion of the status frame.

RAW LONG PERIOD DATA (114 BYTES 18-131)

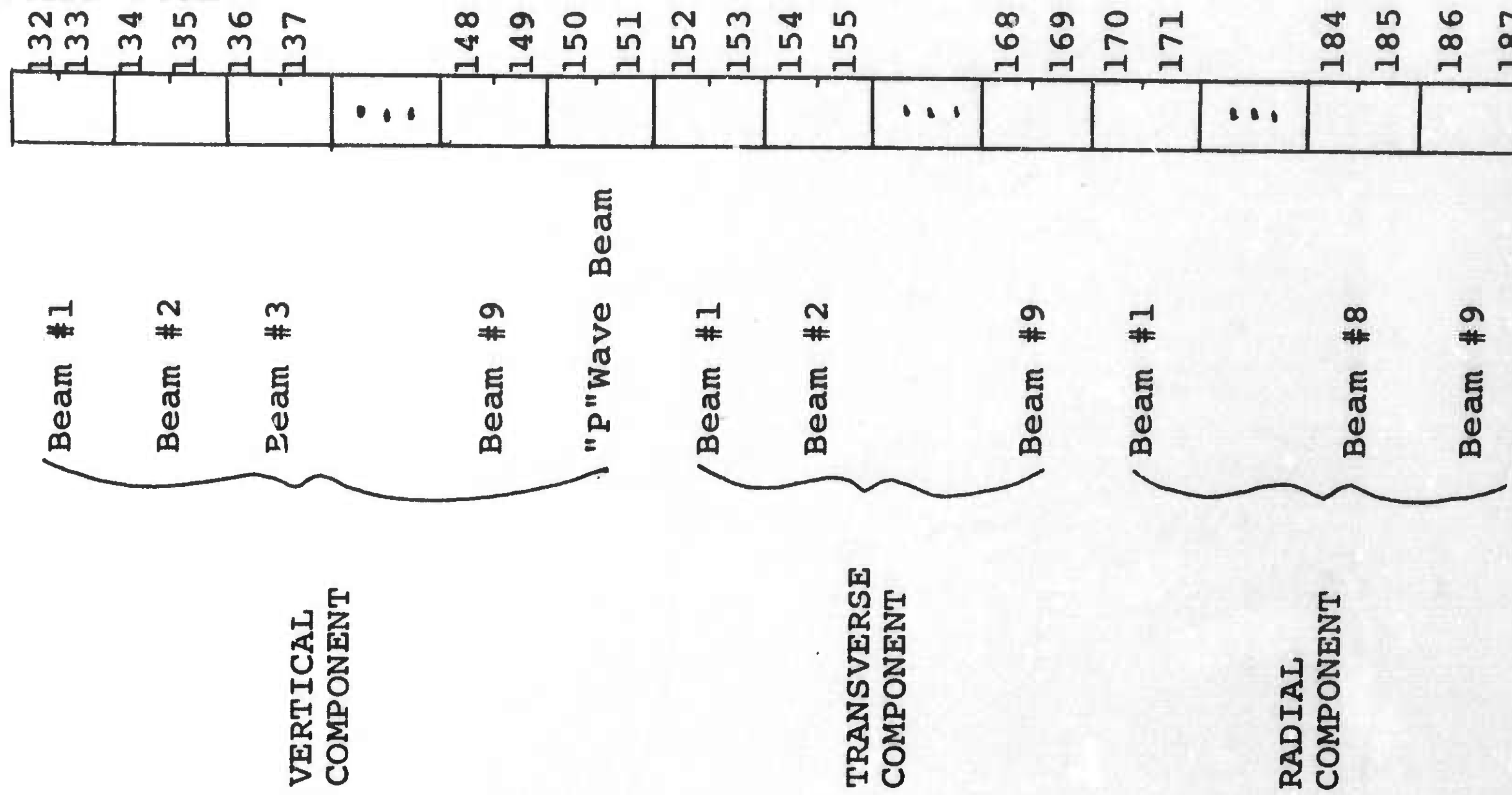


NOTE: Long Period Data is recorded on tape in the format in which it is received. There are two bytes per sample point. The LP Data contains 19 sites with three components per site (the components vary most rapidly).

The bit configuration representing a sample point has: bits 0-3 the GAIN CODE (interpreted as a negative exponential of base 2); and bits 4-15 the FRACTION (2's complement). Allowable gain codes are 0→A HEX DIGITS; illegal gain codes are B→F HEX DIGITS.

BEAM STEER DATA (56 BYTES 132-187)

FRAME BYTES



NOTE: Each beamsteer data point is a two byte integer (S/360 integer halfword). Ten vertical, nine transverse and nine radial beam components are allocated.

The "P" wave is completely represented by its vertical component and this "P" vertical is preceeded by the beam #9 vertical and is followed by the transverse component of beam #1.

FRAME FLAG BYTES (2 BYTES 188-189)

	188	189
FRAME BYTE	0 ... 7	0 ... 7
FLAG BYTE	0	1

	BYTE	BIT	
	0	0	POLYNOMIAL CODE ERROR
	0	1*	LOST MESSAGE-INTERNAL TIMEOUT
	0	2	TIMING ERROR (NON UNITY INCREASING)
C	0	3*	DATA IMPLIES MASKED INSTRUMENT (SET TO ONE BY TI)
	0	4	ILLEGAL TIME WORD ERROR
	0	5*	DATA ADAPTER UNIT CHECK
	0	6*	DATA ADAPTER TIMEOUT
C	0	7*	INVALID GAIN CODE (SET TO ONE BY TI)

BYTE	BIT	
1	0	RESERVED FOR STATUS FRAME USAGE
1	1	
1	2	
1	3*	LATE MESSAGE
1	4*	TIME GAP IN DATA CAUSED PROCESSING REINITIALIZATION
1	5*	SPARE
1	6	NO BEAM DATA PRESENT
1	7	FRAME PROCESSING COMPLETE FLAG

NOTE: * denotes IBM requirement and will be set normal by TI on-line processor.

NOTE: The bit configuration representing an error condition is:

Bit=0 ⇒ no error (normal)
Bit=1 ⇒ error (abnormal)

STATUS FRAME FORMAT

LENGTH		POSITION	DATA FRAME OVERLAYS
5 BYTES	CONTROL PARAMETERS (MICRO-CODE)	0-4	TW
3 BYTES	SITE ERROR TABLE	5-7	SET
10 BYTES	SEIS FUNCTION TABLE	8-17	SET
10 BYTES	QC ENSEMBLE TABLE	18-27	LP
C 10 BYTES	MMC MANUAL STATUS TABLE	28-37	LP
C 10 BYTES	SAAC MANUAL STATUS TABLE	38-47	LP
10 BYTES	BEAM PROCESSING TABLE	48-57	LP
4 BYTES	DATA TIMING WORD	58-61	LP
4 BYTES	BEAM TIMING WORD	62-65	LP
48 BYTES	QC PARAMETERS	66-113	LP
C 2 BYTES	(RESERVED)	114-115	LP
C 15 BYTES	IBM-DEFINED BEAM STATUS INDICATORS	116-130	LP
1 BYTE	ARRAY CONFIGURATION CODE	131-131	LP
56 BYTES	BEAM STEER DEFINITION	132-187	BS
2 BYTES	BLOCK FLAG BYTES	188-189	SB

TOTAL LENGTH IS 190 BYTES

(MICRO-CODE) CONTROL PARAMETERS (5 BYTES 0-4)

BYTE 0	DEFLOAT RIGHT SHIFT PARAMETER
BYTE 1	PRE BBF ROTATION CONTROL PARAMETER 0 NO PRE-ROTATION 1 PRE-ROTATION TO TRIAX ORIENTATION 2 PRE-ROTATION TO V, E, N
BYTE 2	PRE-ROTATION "CFIL" POST SHIFT PARAMETER
BYTE 3	"BBF" POST SHIFT PARAMETER
BYTE 4	POST "BBF" ROTATION "CFIL" POST SHIFT PARAMETER

TABLES (53 BYTES 5-57)

BYTES 5-7	SITE ERROR TABLE--INCLUSIVE .OR. OF 15 FRAMES OF RAW SITE ERROR TABLES. (BYTES 5-7 OF THE 1st THROUGH 15th DATA FRAME OF RECORD).
C BYTES 8-17	SEISMOMETER FUNCTION TABLE--INCLUSIVE .OR. OF 15 FRAMES OF RAW SEISMOMETER FUNCTION TABLES (BYTES 8-17 OF THE 1st THROUGH 15th DATA FRAME OF RECORD). (LAST BIT SET TO ONE BY TI).
C BYTES 18-27	QC ENSEMBLE TABLE--RESULTS OF THE QUALITY CHECKS ON SEISMOMETERS. THIS TABLE IS IN THE SFT FORMAT. (LAST BIT SET TO ONE BY TI).
C BYTES 28-37	MMC MANUAL STATUS TABLE--MANUAL STATUS FROM MMC ON SEISMOMETERS. THIS TABLE IN IN THE SFT FORMAT. (LAST BIT SET TO ONE BY TI).
C BYTES 38-47	SAAC MANUAL STATUS TABLES--SET BY 360 OPERATOR. (TABLE INCLUDING LAST BIT ZEROED BY TI).

C BYTES 48-57 BEAM PROCESSING TABLE--PROVIDES STATUS OF SEISMOMETERS INVOLVED IN THE COMPUTATION OF ON-LINE BEAMS. THIS TABLE IS ALSO IN THE SFT FORMAT. (LAST BIT SET TO ONE BY TI).

TIMING (8BYTES 58-65)

BYTES 58-61 DATA TIMING WORD FOR LP DATA IN THE FIRST FRAME OF THIS RECORD-IN ISRSPS FORMAT.

BYTES 62-65 BEAM TIMING WORD FOR THE BEAMS IN THE FIRST FRAME OF THIS RECORD-IN ISRSPS FORMAT.

NOTE: The ISRSPS format is an integer 4-byte count of deci-seconds since 00:00:00 on Dec. 31 previous year.

QC PARAMETERS (48 Bytes (66-113)

BYTES 66-77 BLOCK POWER FOR COMPONENTS 1, 2 and 3, EACH BEING SPECIFIED AS 4 BYTE INTEGER. THE POWER IS THE SUM OVER SITES OF THE SQUARED DATA POINTS, SCALED BY 1/16. THIS SUM IS EXECUTED FOR EACH COMPONENT AND IS CARRIED OVER ONLY GOOD QC SITES.

BYTES 78-89 LONG TERM AVERAGE POWER (LTA) FOR COMPONENTS 1, 2 and 3, EACH BEING SPECIFIED BY A FOUR BYTE INTEGER.

BYTES 90-93 DECAY CONSTANT USE IN THE LTA COMPUTATION-4 BYTE FLOATING POINT.

BYTES 94-101 BEAM SCALING CONSTANT - 8 BYTE INTEGER.

BYTES 102-105 UPPER POWER TOLERANCE SCALE FACTOR (NOISY SITE CHECK)-FLOATING POINT

BYTES 106-109 LOWER POWER TOLERANCE SCALE FACTOR (DEAD SITE CHECK)-FLOATING POINT

BYTES 110-113 EVENT TRIGGER (FRACTION OF SITES WITH LARGE POWER NEEDED TO TRIGGER EVENT FLAG)-FLOATING POINT

C BYTES 114-115 RESERVED FOR FUTURE EXPANSION

C BYTES 116-130 IBM-DEFINED BEAM STATUS INDICATORS (SET TO ZERO BY TI)

BYTE 131 ARRAY CONFIGURATION CODE

BEAM STEER DEFINITION (56 BYTES 132-187)

BYTES 132-151 FILTER TYPE CODE FOR BEAMS #1 THROUGH #9, AND THE "P" WAVE BEAM (#10). CODE=0 BEAM STEER. EACH CODE IS A TWO BYTE INTEGER.

C BYTES 152-169 BEAM VELOCITY FOR BEAMS #1 THROUGH #9. EACH VELOCITY MEASURES METERS/SEC AS A TWO BYTE INTEGER.

C BYTES 170-187 BEAM AZIMUTH FOR BEAMS #1 THROUGH #9. EACH AZIMUTH IS A TWO BYTE INTEGER SPECIFYING LOOK DIRECTION COUNTED IN CLOCKWISE DECI-DEGREES FROM NORTH.

NOTE: The azimuth and velocity of beam #10 ("P" wave) are not specified.

BLOCK FLAG BYTES (2 BYTES 188-189)

BYTE 188 - BLOCK FLAG BYTE 0 IS A 15 FRAME INCLUSIVE .OR.ed RESULT OF STATUS FRAME BYTE 0. THE BITS REPRESENT:

BIT 0	POLYNOMIAL CODE ERROR
1	LOST MESSAGE-INTERNAL TIMEOUT
2	TIMING ERROR (NON UNITY INCREASING)
3	DATA IMPLIES MASKED INSTRUMENT
4	ILLEGAL TIME WORD ERROR
5	DATA UNIT CHECK
6	DATA ADAPTER TIMEOUT
7	INVALID GAIN CODE

BYTE 189 - BLOCK FLAG BYTE 1. THE BITS REPRESENT:

BIT 0	BLOCK POWER SURGE INDICATOR-COMPONENT 1
1	BLOCK POWER SURGE INDICATOR-COMPONENT 2
2	BLOCK POWER SURGE INDICATOR-COMPONENT 3
3	SPARE
4	"
C 5	CHANGE INDICATOR FOR THE BEAM STEER DEFINITION FIELD. (SET TO 1 BY TI).
6	SPARE
7	BLOCK PROCESSING COMPLETE FLAG

NOTE: Bit Value=0 ⇒ normal
Bit Value=1 ⇒ abnormal

TIME RELATIONSHIPS OF DATA ON AN ALPA LIBRARY TAPE RECORD

The ALPA library tape record contains three fundamental components. These are (1) the data, (2) beam outputs, and (3) a status frame. The beam outputs within a record are associated with data received 30 seconds or 2 tape records earlier. A detailed breakdown of the time to which each entry in the status frame refers is given below:

			REFERS TO
DEFLOAT SHIFT	BYTE	0	DATA IN PREVIOUS RECORD
PRE-ROTATION CONTROL	BYTE	1	DATA IN PREVIOUS RECORD
PRE-ROTATION SHIFT PARAMETER	BYTE	2	DATA IN PREVIOUS RECORD
BBF POST-SHIFT PARAMETER	BYTE	3	BEAMS IN CURRENT RECORD
POST-ROTATION SHIFT PARAMETER	BYTE	4	BEAMS IN CURRENT RECORD
OR'ED SITE ERROR TABLE	BYTES	5-7	DATA IN PREVIOUS RECORD
OR'ED SEISMOMETER FUNCTION TABLE	BYTES	8-17	DATA IN PREVIOUS RECORD
QC ENSEMBLE TABLE	BYTES	18-27	DATA IN PREVIOUS RECORD AND EARLIER
MANUAL STATUS TABLE (MMC)	BYTES	28-37	DATA IN PREVIOUS RECORD
SAAC MANUAL STATUS TABLE	BYTES	38-47	DATA IN PREVIOUS RECORD
BEAM PROCESSING TABLE	BYTES	48-57	DATA IN PREVIOUS RECORD AND EARLIER
DATA TIMING WORD	BYTES	58-61	DATA IN CURRENT RECORD
BEAM TIMING WORD	BYTES	62-65	BEAMS IN CURRENT RECORD
COMPONENT BLOCK POWERS	BYTES	66-77	DATA IN PREVIOUS RECORD
COMPONENT LONG-TERM AVERAGES	BYTES	78-89	DATA IN PREVIOUS RECORD AND EARLIER
TIME CONSTANT FOR LTA COMPUTATION	BYTES	90-93	LTA UPDATE USING DATA IN PREVIOUS RECORD
BEAM SCALING CONSTANT	BYTES	94-101	BEAMS IN CURRENT RECORD
UPPER TOLERANCE SCALE FACTOR	BYTES	102-105	DATA IN PREVIOUS RECORD
LOWER TOLERANCE SCALE FACTOR	BYTES	106-109	DATA IN PREVIOUS RECORD
EVENT TRIGGER FACTOR	BYTES	110-113	DATA IN PREVIOUS RECORD
RESERVED FOR FUTURE EXPANSION	BYTES	114-115	
IBM-DEFINED BEAM STATUS INDICATORS	BYTES	116-130	BEAMS IN CURRENT RECORD
ARRAY CONFIGURATION CODE	BYTE	131	ORDER IN WHICH SENSOR OUTPUTS ARE TRANSMITTED (FIXED BY PROGRAM CODING)
BEAM DEPLOYMENT	BYTES	132-187	BEAMS IN CURRENT RECORD
FLAG BYTE 1	BYTE	188	DATA IN CURRENT RECORD
FLAG BYTE 2	BYTE	189	
	BITS	0-2	DATA IN PREVIOUS RECORD
	BIT	7	BEAMS IN CURRENT RECORD

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) TEXAS INSTRUMENTS INC. Science Services Division P.O. Box 5621, Dallas, Texas 75222	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP —

3. REPORT TITLE

LONG PERIOD ARRAY PROCESSING DEVELOPMENT
QUARTERLY REPORT NO. 3

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

QUARTERLY REPORT NO. 3, 1 November, 1969 through 1 January, 1970

5. AUTHOR(S) (First name, middle initial, last name)

Harley, Terence W.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
10 February, 1970	70	2

8a. CONTRACT OR GRANT NO. Contract No. F33657-69-C-1063 b. PROJECT NO. AFTAC Project No. VT/9707 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) — 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) —

10. DISTRIBUTION STATEMENT

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Chief, AFTAC

11. SUPPLEMENTARY NOTES ARPA Order No. 624	12. SPONSORING MILITARY ACTIVITY Air Force Technical Applications Center-VELA Seismological Center Headquarters, USAF, Washington, D.C.

13. ABSTRACT

This quarterly report is a summary of progress under Long Period Array Processing Development, Contract No. F33657-69-C-1063, during the period 1 November, 1969 to 31 January, 1970.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Long Period Array Processing Development						
Quarterly Report No. 3, 1 November 1969 to 31 January 1970						
On-line Package						
Off-line Package						